Anderson &
Associates, Inc.

Professional Design Services

February 13, 2012

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DEQ - BRRO

Becky France
Virginia Department of Environmental Quality
3019 Peters Creek Road
Roanoke, VA 24019-2738

Re: Mountain Lake VPA Renewal
VPA 02058
A&A JN: 29710

Dear Becky:

Attached is a revised copy (paper and .pdf on CD) of the Mountain Lake Hotel Wastewater VPA Application renewal. It has been revised to address your comments of September 30, 2011. This letter is also provided as a response to a warning letter from DEQ dated February 8, 2012.

If you have any questions or need additional information please let me know (540-552-5592 or crouch@andassoc.com) Thank you.

Sincerely,

ANDERSON & ASSOCIATES, INC.

Gary

Gary S. Crouch
Senior Vice President

GSC/jaf

Cc: Buzz Scanland

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VIRGINIA POLLUTION ABATEMENT PERMIT APPLICATION MOUNTAIN LAKE HOTEL GILES COUNTY, VIRGINIA

December 15, 2011

VPA Permit Reissuance Application
No. VPA02058

Prepared by

Anderson & Associates, Inc.
Consulting Engineers
Blacksburg, Virginia
JN 29710

VIRGINIA POLLUTION ABATEMENT PERMIT APPLICATION
FORM A
ALL APPLICANTS

1. Facility	Name	Mountain Lake Wastewater Treatment Plant
	County/City	Giles County
	Address	115 Hotel Circle, Pembroke, VA 24136
2. Owner	Legal Name	Mary Moody Northen Endowment
	Mailing Address	2628 Broadway, Galveston, TX 77553 (see attached)
	Telephone Number	409-765-9770
	Email address	b.massey@northenendowment.org
3. Owner Contact	Name	H. M. Scanland Jr.
	Title	General Manager
	Mailing Address	115 Hotel Circle, Pembroke, VA 24136
	Telephone Number	540-626-7125
	Email address	bscanland@mountainlakehotel.com

4. Existing permits (e.g., VPA, VPDES; VWP, RCRA; UIC); other:

Agency	Permit Type	Permit Number
VDEQ	VPA	VPA02058

5. Nature of Business: Mountain Lake is a resort offering 101 rental units, a 125-seat dining room, and conference and recreational facilities. While the system is designed for year-round operation, the facilities are currently operated seasonally, with the exception of the Blueberry Ridge cabins and meeting facilities which remain open during winter.

SIC Code(s):	7011		

6. Type of Waste:
(check box as appropriate)

	Proposed	Existing
Animal Waste (complete Form B)	☐	☐
Industrial Waste (complete Form C)	☐	☐
Land Application of Municipal Effluent (complete Form D, Part I)	☐	☒
Land Application of Biosolids/Sewage Sludge (complete Form D, Part II)	☐	☐
Reclamation and/or Distribution of Reclaimed Wastewater (Application Addendum)	☐	☐

7. General Location Map:

VIRGINIA POLLUTION ABATEMENT PERMIT APPLICATION
FORM A
ALL APPLICANTS

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system or those persons directly responsible for gathering information, the information submitted is to the best of my knowledge and belief true, accurate and complete. I am aware that there are significant penalties for submitting false information including the possibility of fine and imprisonment for knowing violations. I further certify that I am an authorized signatory as specified in the VPA Permit Regulation (9VAC25-32).

Signature:	Betty Massey	Date:	2/3/12
Printed Name:	Betty Massey		
Title:	Executive Director		

Further Explanation of Application Items

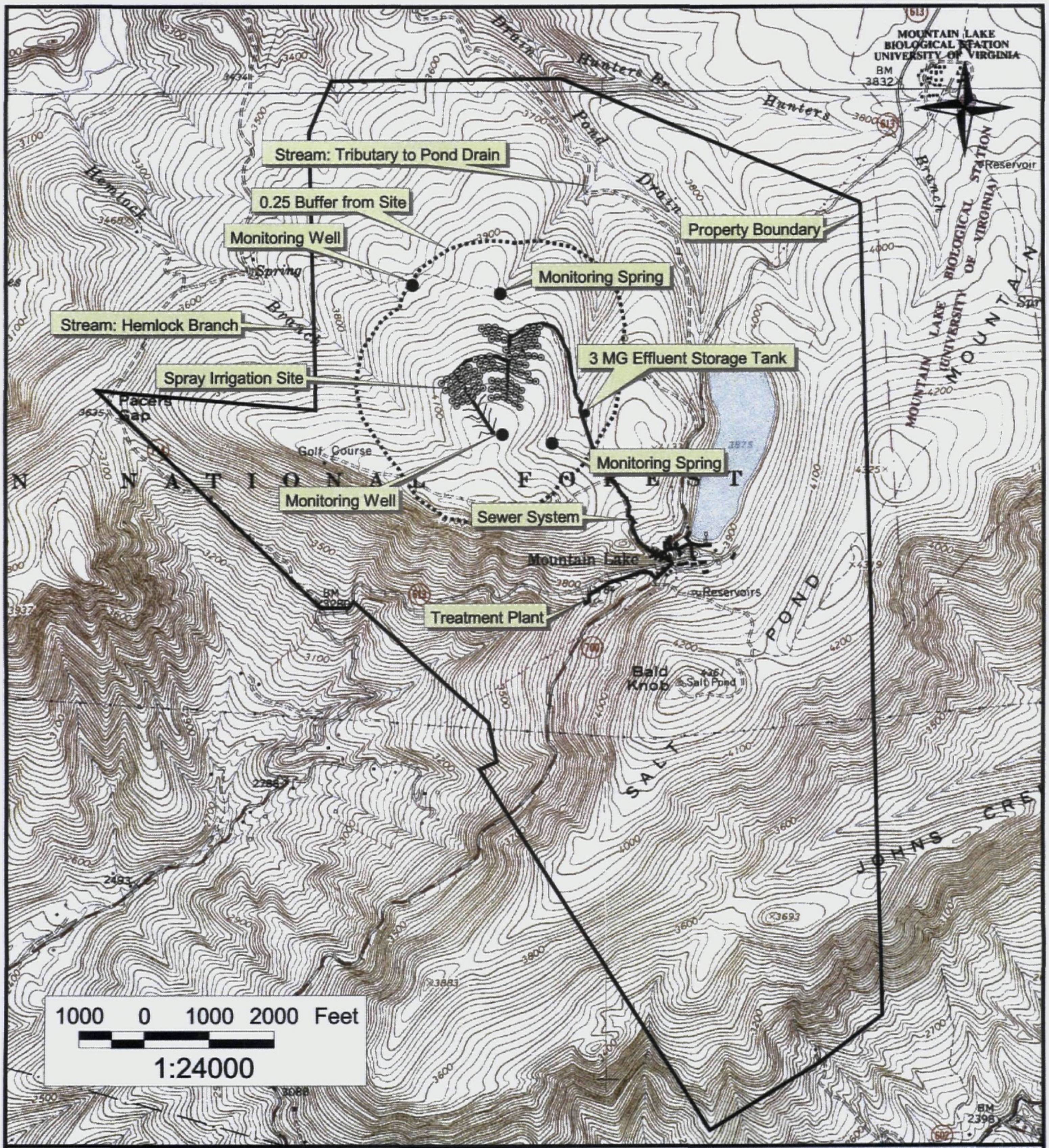
Item 2: The resort as well as the wastewater treatment facilities are managed by Galtex Corporation and all normal business is handled by the General Manger at the site:

Mr. H.M. Scanland, General Manager
115 Hotel Circle
Pembroke, VA 24136
(540)-626-7121

The property is actually owned by a private foundation:

Mary Moody Northen Endowment c/o
Betty Massey
2628 Broadway Street
Galveston, Texas 77550
(409)-765-9770

Item 7: A general location map is attached.



Wastewater Treatment Facilities with Spray Irrigation
Mountain Lake, Virginia

ANDERSON & ASSOCIATES, INC.
Professional Design Services
www.andassoc.com
Virginia - North Carolina - Tennessee
100 Ardmore St.
Blacksburg, VA 24060
540-552-5592

MOUNTAIN LAKE

VIRGINIA POLLUTION ABATEMENT PERMIT APPLICATION

FORM D

MUNICIPAL EFFLUENT AND BIOSOLIDS

PART D-I LAND APPLICATION OF MUNICIPAL EFFLUENT

General Information

1. *Facility Name*

Mountain Lake Wastewater Treatment Plant

2. *Briefly describe the design and provide a line drawing of the wastewater treatment facility which relates the various components of the treatment system including source(s), treatment unit(s) disposal alternatives and flow estimates from the various process units.*

A detailed location map is provided in **Attachment A**. Schematic diagrams of the system layout, and a hydraulic profile are contained in **Attachment B**.

(1) General Plant

The wastewater treatment system consists of four major components. The collection system conveys wastewater from its source to the treatment plant. The treatment plant then treats the wastewater reducing the solids and soluble organic components. The treated wastewater is then pumped, by pumps located at the plant, to a storage tank. During the winter months when the ground is frozen, the wastewater is stored in the tank. During the remaining portion of the year treated wastewater is pumped from the tank and applied to the land. The final component, the irrigation system, consists of piping and spray nozzles used to convey and distribute the treated wastewater in the forest. Within the irrigation system the microorganisms, plants, and soils present in the forest, compose a living filter which provides final cleansing of the wastewater before it makes its way back into the groundwater.

(2) Collection System

a. Piping - The collection system consists of a conventional gravity sanitary sewer system designed in accordance with the Virginia Sewage Regulations. Pipe size is 8 inches on collection sewers while 4 and 6 inch laterals are used where appropriate. PVC sewer pipe is used because of the need to prevent infiltration and because of the corrosive soils on the site.

b. Pump Station - Most of the facilities on the site are sewered by gravity. The Main Lodge, the Barn/conference center, Chestnut Lodge, and the Lakeview Lodge are presently served by gravity sewer. Eight cottages within the lake basin are located at elevations too low to be served entirely by gravity. A pump station within the lake basin is used to serve these cottages.

The pump station contains dual pumps of the slide rail submersible grinder type. A spare pump identical to those installed is provided. Wastewater entering the pump station is screened.

(3) Treatment Plant

a. Layout - The nucleus of the treatment system is a package extended aeration plant. The plant is installed below grade outside and the clarifier is enclosed within the building. The building, which is located in the maintenance area, is finished to match the outside appearance of the adjacent structures. In addition to the package treatment plant the building houses the mechanical equipment, controls, high pressure effluent pumps (for pumping to the storage site), and a small office/lab room.

b. Preliminary Treatment - Preliminary treatment consists of grit removal and screening of wastewater prior to equalization. Flow is directed to a manually cleaned bar screen followed by a gravity grit settling channel. The channel is manually cleaned and has a mud valve to allow washing of the channel. Wash out water is directed to a small sand dewatering filter. The flow from the grit channel and the filtrate from the grit dewatering filter are directed to the Equalization Basin.

c. Equalization Basin (Surge Tank) - The equalization basin is sized to hold 12,000 gallons or roughly one-third of the maximum projected daily flow. Flow is regulated leaving the basin using a submersible pump flow regulator box combination. Submersible pumps, controlled by float switches, pump to the flow regulator box. The discharge can be easily regulated by adjusting overflow weirs in the box. When the submersible pump discharge exceeds the weir head it simply overflows the chamber back into the equalization tank.

d. Aeration Basin - Treatment is provided using the extended aeration modification of the activated sludge process. The aeration basin is sized to allow 37-hour detention at the average daily flow rate of 35,000 gpd. Based on a BOD5 loading of 89.3 pounds per day (306 mg/l) 160 cubic feet per minute of air is needed in the basin. The aeration basin has also been subdivided into two chambers. The first has a volume of 16,900 gallons and the second a volume of 37,200 gallons. The tank was subdivided during construction to facilitate future operation of the plant with separate anoxic and aerated zones for biological nitrogen removal. The plant has operated with the baffles removed between the two chambers as a conventional extended aeration plant.

e. Clarifier - The clarifier is of the center feed-perimeter discharge circular type with mechanical sludge collection and skimming. Sludge is removed by means of an air lift pump. Total detention time at maximum daily flow is approximately four hours.

f. Sludge Holding Tank - Settled sludge which is not recirculated to the aeration tank is wasted to a sludge holding tank. While the intent of the tank is merely to hold sludge until it can be hauled to an acceptable treatment and disposal site, it should be operated as a batch aerobic digester. By aerating and settling the sludge, some solids reduction is achieved and the solids concentration is increased. This results in reduced hauling and treatment costs. The sludge holding tank is sized to hold sludge for a minimum of 30 to 45 days. The 9,300 gallon capacity is adequate to hold sludge for 65 days if a 3 percent solids content is achieved.

g. Disinfection - Disinfection of the treated effluent is provided by chlorination. Chlorine is applied using a four-tube tablet chlorinator prior to the effluent pump wetwell. Chlorine contact is provided in the force main between the treatment plant and the effluent storage tank. The 3594 feet of 4 inch force main provides a volume of 2299 gallons and detention time of 38 minutes in addition to the contact time in the effluent pump wetwell. While plug flow conditions in the force main provide excellent conditions for contact, additional contact time is also achieved in the storage tank.

Because the end of the force main is remote and can only be sampled when the effluent pumps are running, it is recommended that chlorine sampling be conducted at the treatment plant ahead of contact in the force main. The chlorine dose can be monitored at the plant to achieve a typical residual required at the force main discharge.

h. Effluent Pumps - By treating the wastewater prior to pumping, higher head closed impeller pumps are used without the threat of clogging by solids. The solids remaining in the effluent are typically very small, light solids, free of grit that will easily pass through the closer tolerances of the closed impeller pumps without causing excessive wear. Since the flowrates are equalized through the plant, the average design flow of 35,000 gpd, or 61 gpm, is provided by each pump. The approximate static head is 385 feet and multistage pumps are required.

i. Lab Facilities - A small lab is provided in the treatment building to enable routine monitoring of some background parameters. The lab is also used to assist in process control. More complex testing, such as that required for groundwater monitoring, is performed by a commercial laboratory. Details about the groundwater monitoring system are provided in **Attachment G**.

(4) Storage System

The storage facilities are located in a hollow approximately 3,000 feet northwest of the hotel. The actual storage facility is a covered, 3 million gallon, concrete tank. The storage tank has been sized to store all wastewater projected to be generated during a severe winter. From temperature records it was determined that average monthly temperatures below freezing have been noted for as long as four months. While this condition had occurred only twice in the fourteen years of record available at the time of design, it was used as the basis of design for the storage tank. Because the tank is covered, precipitation does not influence the capacity requirements.

(5) Spray Irrigation System

The irrigation system consists of two major components: the pumps and the spray fields. With the pumps are included the associated mechanical equipment, piping and controls. The spray fields consist of the living filter system and the irrigation equipment used to apply wastewater to the filter.

The pumps are located as close to the storage facilities as possible. The pumps are designed to take suction directly from the storage tank eliminating the need for an additional pump well. The stored effluent is then pumped through a 4-inch force main to the spray fields, which vary in elevation. The difference in elevation between the pump and lowest spray fields is about 30 feet while the maximum difference to the highest fields is 170 feet.

The spray fields are located approximately 4,000 feet northwest of the hotel, and approximately 1,000 feet west of the storage facilities. The fields are located in mature forest with surface slopes ranging from 4 to 12 percent. To minimize system damage during extended cold periods the system has been designed to provide gravity drainage of the entire force main back to the irrigation pumps. The pumps have the ability to pump the drained water back into the storage tank.

3. *Briefly describe the disposal of any solid or sludge waste materials.*

The sludge wasted from the facility is hauled to the Peppers Ferry Regional Wastewater Treatment Plant operated by the Peppers Ferry Regional Wastewater Authority in Pulaski County, Virginia. Since no sludge is land applied, this application does not contain sections II or III for infrequent or frequent land application.

4. *List all industrial contributors to the wastewater treatment facility.*

There are no industrial contributors to the facility.

5. *Submit a copy of any leasing agreements related to the treatment works and the use or management of the application fields not under direct ownership of the applicant.*

All facilities are located on property under the ownership and control of the facility owner.

6. *All Privately Owned Treatment Works (PVOTW) designed to serve 50 or more residences must be registered with the State Corporation Commission (SCC) prior to applying for a permit. Provide a copy of the SCC Certificate of Incorporation (for Virginia based operations) or the Certificate of Authority (for out of state operations) with the application.*

Not applicable.

Design Information

Note: This section should be completed for each alternative effluent application system.

Waste Characterization

7. *Provide the design flow of the wastewater treatment plant.*

Wastewater flow generated at the hotel is directly dependent on the number of guests using the facility. The quantity of wastewater generated which is independent of the number of guests is so small that it is insignificant in these projections.

For the original wastewater system design, the per capita flowrate was first determined. A review of the literature at the time of design found normal design values for hotel facilities yielded widely divergent per capita flow rates. Reported rates ranged from 25 to 250 gallons per capita day (gpcd). The original design looked at the facilities (lodges and rooms, dining rooms, recreation facilities, laundry, and employee facilities) and their existing guest capacity to estimate an ultimate guest capacity and associated per capita flowrate. Table 1 in **Attachment C** summarizes these design wastewater flow values. The flows were tabulated by source so the information could be used in the sizing of the wastewater collection system as well as the treatment facilities. Consideration was also given to the fact that all new plumbing fixtures were installed by the time the wastewater facilities came online, including low flush toilets and flush valves and water saving shower nozzles. The projected total wastewater flow at full occupancy was divided by the anticipated maximum number of guests to obtain a per capita flowrate. The wastewater generated per guest was projected to be 100 gpcd.

To project the seasonal variations in wastewater flow, the original design estimated the ultimate occupancy per month and multiplied by the 100 gpcd. Table 2 in **Attachment C** shows these original occupancy estimates and the associated monthly flow rates. The projected average design flow during the highest month was 31,500 gallons per day (gpd), the lowest was 16,400 gpd and the overall average was expected to ultimately reach 23,600 gpd. With an additional reserve capacity, the design flow was estimated at 35,000 gpd.

For design purposes, the Owner desired the ability to accommodate winter operation of the lodge and most facilities. Since the wastewater facilities have been in operation, the lodge has only been in operation one winter. The newer Blueberry Ridge cottages are used during the winter months but winter occupancy at the resort is historically lower than the design projections.

For the original design, the management also wanted the capacity for increased conference trade. Hourly fluctuations in flowrate would normally be increased as more guests' activities become scheduled. Scheduled meals and meeting breaks compress wastewater generation into shorter duration peak flow periods. While normal peak flow factors of 2.5 times average flow would be adequate for design, a peak flow factor of 6.0 times average was used for hydraulic design of the wastewater facilities. The table below summarizes these original design flows:

Original Design Flow Rates

Sewers and Pump Stations	
Maximum Daily Flow	From Table 1 in Attachment C
Peak Design Flow	6.0 x Ave. Daily
Treatment Plant	
Average Daily Flow (Ultimate)	23,600 gpd
Peak Daily Flow (Ultimate)	31,500 gpd
Design Flow	35,000 gpd
Peak Design Flow	6.0 x Ave. Daily = 141,600 gpd

Table 3 in **Attachment C** has values for the monthly flow rate derived from the daily flow meter readings at the treatment facility for the prior year (Sept. 2010 – Aug.2011). The values reported in the facility's monthly reports are listed in the "Reported Flow" column. A review of the flows revealed flow patterns that appeared abnormal from prior years. The meter is reported to be in calibration. The irregular flows are reported to reflect substantial changes in the occupancy at the hotel. Flows were higher than normal during February through May due to a contract that kept the Blueberry Ridge cabins occupied during this time. Flows during the "normal" vacation season (June – September) were lower than normal due to the unfavorable economy and low lake levels.

Table 3 shows that the Mountain Lake facility is currently operating, on average, at slightly below the original design flows. During the winter months, there is less occupancy than originally expected, so these flows are lower. During the summer, the flows are significantly below design and those experienced during initial operations. Overall, all months during the past year were less than the original design flow of 35,000 GPD.

8. *Provide a sewage effluent characterization in accordance with Part D-III of the application. For a proposed facility, estimates based on data obtained from other similar facilities may be used. More than one sample may be required if the effluent may be expected to exhibit diurnal or seasonal variation.*

Effluent characteristics are contained in Part D-III. While the flowrates fluctuate greatly depending on occupancy, the nature of the wastewater is relatively consistent. All effluent is pumped to the storage tank prior to final land application. The tank tends to equalize any variation in the treated effluent characteristics when there are any.

9. *Provide calculations describing the nutrient value of the effluent as mg/l nitrogen (PAN), phosphorus (P_2O_5), potassium (K_2O) and any liming effects which may occur from land application.*

Organic and chemical loading are of importance in sizing the treatment facilities and in determining the acceptability of the wastewater for land application. While the five day biochemical oxygen demand (BOD5) would be expected to be slightly higher than for a typical domestic wastewater, early testing yielded lower than normal concentrations. The projected BOD5 and Total Suspended Solids (TSS) loads used for design are shown in **Attachment C** in Tables 4 and 5. The anticipated load for both BOD5 and TSS is 89.3 pounds per day. The average concentration at design flow would thus be 306 milligrams per liter (mg/l).

Total phosphorus concentrations measured in the existing hotel wastewater were initially in the range of 5 to 8 mg/l. Analyses of monitoring springs in the area did not show the presence of orthophosphates. Analyses of the well conducted by the Virginia Department of Health indicated total phosphate levels at 0.1 mg/l with ortho-phosphate levels measured at 0.01 mg/l.

Nitrogen levels measured in wastewater samples from the hotel complex are typical of a medium to low strength domestic waste. Total nitrogen levels calculated ranged from 26 to 41 mg/l, with organic and ammonia nitrogen as the principal components. Nitrite plus nitrate levels ranged from .01 to 1.96 mg/l. Total nitrogen decreases due to treatment, with ammonia gas and free nitrogen being released to the atmosphere. Some of the remaining organic and ammonia nitrogen as well as the nitrites are converted to nitrates as a result of the aerobic treatment process. A recent sample of the treated effluent contained nitrates at 0.51 mg/l with ammonia and Total Kjeldahl nitogen (TKN) not detected.

Trace elements including heavy metals have been quantified in the wastewater stream. The analysis showed that all elements analyzed are not detectable with the exception of copper which is below the EPA maximum recommended levels for drinking water. **Attachment C** summarizes the computed and measured characteristics of wastewater entering the proposed treatment facilities, as anticipated during design.

In addition, the chemical data accompanying the soils report (**Attachment F** and detailed in item 17) indicates that the biological system has developed on soils which are very acid. The natural soil pH of the site ranges from about 3.3 to 3.7. In view of the fact that the existing vegetative environment has developed under these acid soil conditions, it is not advisable to modify the natural soil pH by liming. It is felt that this could have a serious negative effect on the existing environment.

The sewage effluent has been shown to have a pH which is near neutral and when applied will have a slow buffering effect on the environment. Some changes in the environmental character have undoubtedly occurred; however, and will continue to occur over a longer period of time and as the result of natural buffered reactions.

Storage and Land Application Requirements

10. *Provide calculations justifying storage and land area requirements for wastewater application including an annual water balance on a monthly basis incorporating such factors as precipitation, evaporation, evapotranspiration, soil hydraulic conductivity, wastewater loading, dry periods, and monthly storage (input and drawdown). Provide daily, weekly and annual hydraulic loading rates (maximum and average).*

    All facilities must be designed and operated to prevent any discharge to State waters except in the event of a 25 year, 24 hour or greater storm event. DEQ recommends the storage capacity be sufficient to store the entire daily design flow of the treatment works for the duration of the winter months, when land application may be restricted, with a minimum of 60 days storage capacity where adequate climatological data are not available.

(1) Storage

The storage tank has been sized to store all wastewater projected to be generated during a severe winter. From temperature records it was determined that average monthly temperatures below freezing have been noted for as long as four months. While this condition had occurred only twice in the fourteen years of record prior to design, it is used as the basis of design for the storage tank. Because the tank is covered, precipitation does not influence the capacity requirements.

The projected flowrates during the winter season reflected reduced occupancy over that expected during the summer season. The storage capacity takes this into account while still providing a margin of safety to account for unknowns. A backup or reserve capacity of 10 days is required by the Virginia Department of Health in addition to the projected storage needs. A storage capacity of 3 million gallons is provided which includes a 13 percent factor of safety over the projected worst case storage needed. The original capacity provided is computed below:

Original Design - Storage Tank Capacity

MONTH	DAYS	FLOW (gpd)	VOLUME (gallons)	PERCENT
December	31	26,700	827,700	28
January	31	21,400	663,400	22
February	29	21,400	620,600	20
March	31	16,400	508,400	17
Backup	10	23,600	236,000	8
Reserve	6	23,600	143,900	5
Total	138		3,000,000	100

Note: Monthly flows based on estimate in Table 2 in **Attachment C**.
Backup and reserve flows based on average daily flow rate.

Current Flow - Storage Tank Capacity (Winter 2010-2011)

MONTH	DAYS	FLOW (gpd)	VOLUME (gallons)	PERCENT
December	31	7100	220,100	7
January	31	4100	127,100	4
February	28	8300	232,400	8
March	31	11,300	350,300	12
Backup	10	23,600	236,000	8
Reserve	78	23,600	1,834,100	61
Total	209		3,000,000	100

Note: Monthly flows based on values in Table 3 in **Attachment C**.
Backup and reserve flows based on design average daily flow rate.

See **Attachment H** for actual original calculations. Since the original design, projected winter operations at Mountain Lake have been scaled back. The second table above shows the storage tank capacity based in the winter of 2010-2011 flow data and the extra 88 days of storage the tank provides. The newer Blueberry Ridge Cabins are operational and are used particularly on weekends during winter months but flows still do not approach the original design.

(2) Land Area

The original application rates were computed based on the ability of the forest soil system to handle both the additional hydraulic and nitrogen loads. The allowable hydraulic load is based on the ability of the soil to accept and pass water without creating runoff from the site. Since the precipitation rate exceeds the estimated evapotranspiration rate, the excess precipitation will contribute to the water percolating through the soil. The safe hydraulic capacity of the soil has been reported by EPA to be between 4 and 25 percent of the percolation rate. Using the most conservative rate of 4 percent and a measured percolation rate of 45 minutes per inch, the allowable percolation rate of 302 inches per year is computed. Deducting the excessive precipitation, a safe hydraulic loading rate, based on soil permeability, of 266 inches per year is computed.

The allowable nitrogen loading is based on the nitrogen uptake rate of the forest and on the allowable nitrate content of the water percolating into the groundwater table under the site. The nitrogen uptake rate of the mature forest and understory vegetation at the site is estimated at 50 pounds per acre year. The maximum allowable nitrate concentration in percolate water leaving the site is 5 mg/l. The maximum allowable nitrogen loading based on equations developed by EPA would be 127 lb./acre yr. at the projected flowrates.

Based on site conditions, Mountain Lake Hotel's soil consultant in cooperation with the agronomist for the Virginia Cooperative Extension Service, established an acceptable hydraulic loading rate of 30 inches per acre. The controlling factor in setting this rate was total nitrogen loading. Using an application rate of 30 inches per year and a wastewater flowrate of 35,000 gpd, 15.7 acres of active spray field was required.

Since the daily flowrate of wastewater is projected to average only 23,600 gpd on a yearly basis, the required active spray field area is actually only 10.6 acres at 30 inches per year. In order to meet the requirements of the Virginia Sewage Regulations of a 25 percent reserve area, and to insure system reliability, a total spray area of 16.0 acres was developed initially. At start-up of the system it was estimated that only 6.3 acres would be needed to remain within the recommended application rates and 11 acres would be required at design flow.

The 16.0 acre spray area is subdivided into 16 one-acre subsystems. Each subsystem contains 6 sprinkler heads which are located at approximately the same elevation. By minimizing dynamic pressure losses and discharging at the same elevation, the discharge rates at each sprinkler head are kept near uniform within each subsystem. Thus, the entire system is balanced by regulating the discharge pressure to each subsystem.

Regulation is accomplished by means of a control valve for each subsystem. The valves are a combination valve with a solenoid controlled open/close position, and a manual actuated throttle which limits the extent of the open position. Once the throttling rate has been manually set, each valve can be controlled from the control panel located with the irrigation pumps. Control valves will be normally closed so that system failure will result in no discharge. No check valves have been placed on the subsystems so the entire system can be back drained to the storage tank at the end of the season from the control panel.

Attachment I contains an excerpt from the Mountain Lake Wastewater Treatment Plant O&M Manual that further details the timing of the effluent application.

11. *Provide calculations justifying the land area requirements for land application of sewage effluent taking into consideration average productivity group, crop(s) to be grown and most limiting factor(s), specifically PAN, metal loadings, and Sodium Adsorption Ratio (SAR) or Exchangeable Sodium, where applicable. Demonstrate the most limiting factor for land application on an annual and site life basis.*

The previous section discussed the role of nitrogen in determining the application rate. The detailed nutrient and metal loading computations are contained **Attachment H**. The spray application site is covered with a mature hardwood forest which consists primarily of Northern red oak, Red maple, and Shagbark hickory. No harvesting of timber is anticipated during the life of the wastewater facilities.

In 1989 and 1990, Dr. James Burger and Dong Yeob Kim in the Virginia Tech Department of Forestry conducted a study on the nutrient cycling of the spray irrigation site. Their research was published in *Municipal Wastewater Effects on Nitrogen Cycling in a Mature Hardwood Forest,* D.Y. Kim, 1992. Virginia Polytechnic Institute and State University, Department of Forestry, Doctoral Dissertation. Their research looked at the changes in the Nitrogen cycling caused by different spray irrigation rates. They studied the nitrogen cycling in vegetation and the upper soils layers, but did not study the groundwater nitrogen levels. Compared to other spray irrigation system in forests, they noted that Mountain Lake had lower nitrogen application rates. As a mature hardwood system, they found that different irrigation rates did little to affect plant uptake rates, but did accelerate litter decomposition rates. They concluded that the operational irrigation rate used by Mountain Lake was, "low enough to be within the N assimilation capacity of this hardwood forest at this time." (p. 108)

Site Characterization

Note: *A site characterization is required for each land application site on a field by field basis and for each storage facility. Site booklets organized by Operator/Land Owner and County are preferred.*

Divide the land application site into individualized units of fields on the basis of agronomic management practices. For example, soils which are similar for productivity or pH adjustment which are adjacent to each other should be grouped as one field if they can be anticipated to receive effluent on similar schedules. Distinctly different soils which may require different agronomic management should be designated separately. For convenience in meeting permit reporting requirements, keep field units small.

12. *Provide a general location map which clearly indicates the location of all the land application sites related to this permit application. (See General Instructions for Map Requirements.)*

    Attachment A contains a map with the general features.

13. *Provide a topographic map of sufficient scale (5 foot contour preferred) clearly showing the location of the following features within 0.25 mile of the site. More than one map may be required if the land application site(s) or treatment/storage facilities are not in close proximity. Provide a legend and approximate scale. Clearly mark field and property boundaries. (See Instructions for map requirements.)*

    The map in **Attachment A** also indicates the following features:

a. *Proposed or existing ground water monitoring wells*	Groundwater Monitoring Wells shown
b. *General direction of ground water movement*	Assumed in direction of surface slopes
c. *Water wells, abandoned or operating*	None
d. *Surface waters*	Hemlock Branch and Pond Drain
e. *Springs*	None
f. *Public water supply(s)*	None
g. *Sinkholes*	None
h. *Underground and/or surface mines*	None
i. *Mine pool (or other) surface water discharge points*	None
j. *Mining spoil piles and mine dumps*	None
k. *Quarry(s)*	None
l. *Sand and gravel pits*	None
m. *Gas and oil wells*	None
n. *Diversion ditch(s)*	None
o. *Agricultural drainage ditch(s)*	None

p. *Occupied dwellings, including industrial and commercial establishments*	None
q. *Landfills or dumps*	None
r. *Other unlined impoundments*	None
s. *Septic tanks and drainfields*	None
t. *Injection wells*	None
u. *Rock outcrops*	None in spray field location

14. *For each land application site, provide a site plan, preferably topographically based, of sufficient detail to clearly show any landscape features which require buffer zones or may limit land application. Clearly show the field boundaries, property lines, and the location of any subsurface agricultural drainage tile, as appropriate.*

Attachment D contains two site layout maps with detailed topography and location of the spray irrigation system. The first map shows the slopes for the spray irrigation site and the second map contains only the contour information for the site.

Provide a site plan legend which identifies the following landscape features:

a.	*Drainageways*	None
b.	*Rock outcrops*	None in spray field location
c.	*Sink holes*	None
d.	*Drinking water wells and springs*	None
e.	*Monitoring wells*	Shown
f.	*Property lines*	Outside of site (shown on Attachment A)
g.	*Roadways*	Shown
h.	*Occupied dwellings*	None in proximity to site
i.	*Slopes (greater than 8% by slope class)*	Shown (see discussion below)
j.	*Wet spots*	None
k.	*Severe erosion*	None
l.	*Frequently flooded soils (SCS designation)*	None
m.	*Surface waters*	Outside of site (shown on Attachment A)

The placement of the spray heads during the original design was based on detailed analyses (discussed in next section) and slopes. **Attachment D** indicates those land areas that had acceptable soils based on the analyses and slopes. The original slope goal was to avoid areas with greater than 20 to 25% slopes and try to be below 8%. **Attachment D** shows that most of the land area under the sprinklers is less than 8% (lightest shading) and a majority of the remaining area is less than 15% slope. The slope calculation was based on the 2 ft. contour lines.

15. *Provide a detailed soil survey map, preferably photographically based, with the field boundaries clearly marked. (A USDA-SCS soil survey map should be provided, if available.)*

Attachment E contains the USDA-SCS Soil Survey mapping for the site.

Provide a detailed legend for each soil survey map which uses accepted USDA-SCS descriptions of the typifying pedon for each soil series (soil type). Complex associations may be described as a range of characteristics. Soil descriptions should include the following information:

- a. *Soil symbol*
- b. *Soil series, textural phase and slope class*
- c. *Depth to seasonal high water table*
- d. *Depth to bedrock*
- e. *Estimated productivity group (for the proposed crop rotation).*
- f. *Estimated infiltration rate (surface soil)*
- g. *Estimated permeability of most restrictive subsoil layer*

Soil symbol	Soil series, textural phase and slope class	Depth to seasonal high water table	Depth to bedrock	Estimated productivity group (for the proposed crop rotation).*	Estimated infiltration rate (surface soil)	Estimated permeability of most restrictive subsoil layer
27C	Lily-Bailegap complex; very stony; Lily: sandy loam; Bailegap: loam; 2 to 15 % slopes	> 6.0 ft.	Lily:20-40 in. Bailegap:40-60 in.	Lily: 4o Bailegap: 3o	0.15 – 0.30 in./hr.	Lily: 0.6 – 6.0 in./hr. Bailegap: 0.6 – 2.0 in./hr.
27E	Lily-Bailegap complex; very stony; Lily: sandy loam; Bailegap: loam; 15 to 35 % slopes	> 6.0 ft.	Lily:20-40 in. Bailegap:40-60 in.	Lily (North asp.): 4r Lily (South asp.): 5r Bailegap (North asp.): 3r Bailegap (South asp.): 4r	0.15 – 0.30 in./hr.	Lily: 0.6 – 6.0 in./hr. Bailegap: 0.6 – 2.0 in./hr.

*Productivity group represents the Woodland Management and Productivity Ordination Symbol, where the numbers represent potential productivity (1: very high; 2: high; 3: moderately high; 4: moderate; 5: low) and letters represent limitations (o: insignificant limitations; r: steep slopes.)

16. *Representative soil borings and test pits to a depth of five feet or to bedrock if shallower, are to be coordinated for the typifying pedon of each soil series (soil type). Soil descriptions shall include as a minimum the following information:*

    a. *Soil symbol*
    b. *Soil series, textural phase and slope class*
    c. *Depth to seasonal high water table*
    d. *Depth to bedrock*
    e. *Estimated productivity group (for the proposed crop rotation).*
    f. *Estimated infiltration rate (surface soil)*
    g. *Estimated permeability of most restrictive subsoil layer*

    Attachment F contains the soils documentation. Soil sampling and analysis was performed by Mathews Soil Consultants in 1984 and 1985 prior to design and the original permit application. Soils were examined on-site by digging backhoe test pits. Over one hundred test pits were examined and logged by Mathews Soil Consultants during their study. Sampling and analysis at the time did not include all the parameters listed above (a-g), but was conducted in accordance with the requirements in effect at the time of the sampling. It is not feasible to reexcavate the backhoe pits at this time to obtain new samples.

    The following items are addressed in the soils report by Mathews Soil Consultants in **Attachment F** or noted otherwise:

    1. Soil texture - shown
    2. Soil color - shown
    3. Depth to gray mottling - shown
    4. Depth to restrictive layers - shown
    5. Infiltration rate - not shown for individual test pits but given as an overall representative rate.
    6. Permeability of restrictive layer - not shown for individual test pits but given as an overall representative rate.

The soils in the site where the spray irrigation site was placed mainly fell into three soils units. These units roughly correspond to certain soil series in the area. The USDA-SCS Soil Survey for the area list the soil series as a Lily-Bailegap complex. Described below are these three soil units and the related soil series.

Soil Unit #1: Bailegap Series

The soils of this unit are deep to moderately deep and well drained. They have developed from colluvium derived primarily from hematite sandstones. Soil colors are predominantly dark red to reddish-brown and soil textures are predominantly loam in the upper 20 to 30 inches with clay loam predominating below 30 inches. Fragment content ranges from 10 to 15 percent to more than 70 percent.

Permeability of the upper loam horizon is moderately rapid because of strong structural development and a high organic matter content. The permeability of the subsoil horizon is moderate primarily because of moderate to strong structural development.

A concept of soil profile characteristics is available by reading soil profiles 104 through 112 in Mathews report.

The soils of this unit are well suited for use as a spray irrigation site because of good permeability and the capability to infiltrate water at a rapid rate. They occur on slopes ranging from about 6 percent to slopes in the order of 20 to 25 percent. Depth to rock ranges from about three feet to more than six feet. Their good water movement characteristics are illustrated by the absence of chroma 2 mottling and the presence of red to dark red colors and strongly developed structural characteristics. It is recommended that spray irrigation rates in the order of 30 acre-inches per year be considered for these soils. The 30 acre-inch per year recommendation is based on the fact that the soils occur on sloping sites and that some soil profiles show rock at a depth of about three feet.

Soil Unit #2: Lily Series

The soils of this site are deep to moderately deep and well to moderately well drained. They are developed from a thin veneer of dark reddish-brown soil materials associated with hematite sandstones which are underlined by soils developed from thinly bedded sandstones and shales of the Juniata Formation. The upper soil profile is loamy and has good infiltration characteristics similar to those of Unit #1. The subsoils have developed from weathered sandstones and shales and contain higher clay contents and are somewhat less permeable than those of Unit #1. Soil colors in the topsoil horizons are dark brown to dark reddish-brown and black with good permeability. Subsoil colors range from dark reddish-brown to yellowish-red, strong brown, yellowish-brown and sometimes contain gray and white mottles at depths ranging from about 30 to 48 inches below the soil surface.

Permeability of the upper soil profile is moderately rapid and for the subsoil horizons is moderate to moderately slow. Representative soil profile descriptions can be evaluated by looking at descriptions numbered 160 through 172 in Mathews report.

The soils of this unit are moderate to fair for use as spray irrigation sites. They are limited by occupying sloping positions which range from about 3 percent to slightly more than 20 percent. Depth to bedrock ranges from 36 to 60 inches and permeability of the slowest horizon is in the order of 1/8 inch per hour.

It is suggested that this area be utilized as a reserve irrigation site with a maximum application rate in the order of 20 to 24 acre-inches per year.

Soil Unit #3: Lily Series (Interbedded Shale near surface)

The USDA-SCS Soil Survey mentions that both Bailegap and Lily soil series will contain interbedded shale. It appears that this unit is similar to the previous unit, but the shale layer is closer to the surface.

The soils of this unit have developed from a thin veneer of dark reddish-brown colluvial material associated with hematite sandstone which is underlain by clayey soils developed from stratified shale and sandstone of the Juniata Formation. The soils occupy gently rolling topography and have developed heavy clay subsoils. Gray mottles present are indicative of seasonal perched water tables which occur at depths ranging from 20 to 42 inches below the soil surface. These soils are not recommended for use as spray irrigation sites. The soils of this unit can be evaluated by studying soil profile descriptions L-7 through L-13, or soil profiles 173 through 188 in Mathews report.

17. *Collect and analyze soil samples for the following parameters for each field, weighted to best represent each of the soil borings performed for Item I6.*

    a. *Soil organic matter (%)*
    b. *Soil pH (std. units)*
    c. *Cation exchange capacity (meg/l00g)*
    d. *Total nitrogen (ppm)*
    e. *Organic nitrogen (ppm)*
    f. *Ammonia nitrogen (ppm)*
    g. *Nitrate nitrogen (ppm)*
    h. *Available phosphorus (ppm)*
    i. *Exchangeable sodium (mg/l00g)*
    j. *Exchangeable calcium (mg/l00g)*
    k. *Copper (ppm)*
    l. *Nickel (ppm)*
    m. *Zinc (ppm)*
    n. *Cadmium (ppm)*
    o. *Lead (ppm)*
    p. *Chromium (ppm)*
    q. *Manganese (ppm)*
    r. *Particle size analysis or USDA textural estimate (%)*
    s. *Hydraulic conductivity (in/hr.)*

The end of **Attachment F** contains the laboratory analysis results for the 3 soil units described in the previous section. These analyses were performed in 1986 and cover most of the parameters in the table above. Those not covered are nitrate nitrogen, particle size analysis, and hydraulic conductivity.

Crop and Site Management

18. *Relate the crop nutrient needs to anticipated yields, soil productivity rating and the various fertilizer or nutrient sources from effluent and chemical fertilizers.*

    If the effluent may be expected to possess unusual properties, provide a description of any plant tissue testing, supplemental fertilization or intensive agronomic management practices which may be necessary.

    As mentioned earlier, the spray application site is covered with a mature hardwood forest which consists primarily of Northern red oak, Red maple, and Shagbark hickory. No harvesting of timber is anticipated during the life of the wastewater facilities. **Attachment H** contains the calculations for the spray irrigation water and nutrient loading levels and provides estimates of site life based on nutrient uptake levels.

19. *Using a narrative format and referencing any related charts, describe the proposed cropping system. Show how the crop rotation and management will be coordinated with the design of the land application system. Include any supplemental fertilization program, and the coordination of tillage practices, planting and harvesting schedules and timing of land application.*

    As mentioned earlier, the spray application site is covered with a mature hardwood forest which consists primarily of Northern red oak, Red maple, and Shagbark hickory. No harvesting of timber is anticipated during the life of the wastewater facilities. The only part of the irrigation process which will vary over time will be the lack of irrigation during winter months. The timing and design basis of the irrigation is discussed earlier in section 10.

VIRGINIA POLLUTION ABATEMENT APPLICATION

FORM D

MUNICIPAL EFFLUENT AND BIOSOLIDS

PART D-III EFFLUENT CHARACTERIZATION FORM

1. Facility Name: Mountain Lake Wastewater Treatment Plant
2. Source or Generator: Mountain Lake Hotel and Facilities
3. Type of Treatment: Conventional Extended Aeration
4. Degree of Treatment: Secondary Treatment
5. Provide at least one analysis for each parameter listed under effluent. Upon review, additional analyses may be required by DEQ.

Parameter	Effluent	
BOD_5	N/D	mg/l
TSS	N/D	mg/l
TRC	2.4	mg/l
Percent Solids	0	%
pH	6.19	S.U.
Nitrogen, (Nitrate)	0.51	mg/l
Nitrogen, (Ammonium)	N/D	mg/l
Nitrogen, (Total Kjeldahl)	N/D	mg/l
Phosphorus, (Total)	N/D	mg/l
Potassium, (Total)	0.549	mg/l
Sodium	6.24	mg/l

*Analysis by REI Consultants, Inc. of sample on 7/27/2011 except sodium on 01/13/2012.

6. Provide at least one analysis of any other pollutants which you believe may be present in the effluent. Upon review, additional analyses may be required by DEQ.

Parameter	Effluent	
Lead	N/D	mg/l
Cadmium	N/D	mg/l
Copper	0.0141	mg/l
Nickel	N/D	mg/l
Zinc	N/D	mg/l
Other		mg/l

*Analysis by REI Consultants, Inc. of sample on 01/13/2012.

Rev. 4-2009

VIRGINIA POLLUTION ABATEMENT APPLICATION

FORM D

MUNICIPAL EFFLUENT AND BIOSOLIDS

PART D-V NON-HAZARDOUS WASTE DECLARATION

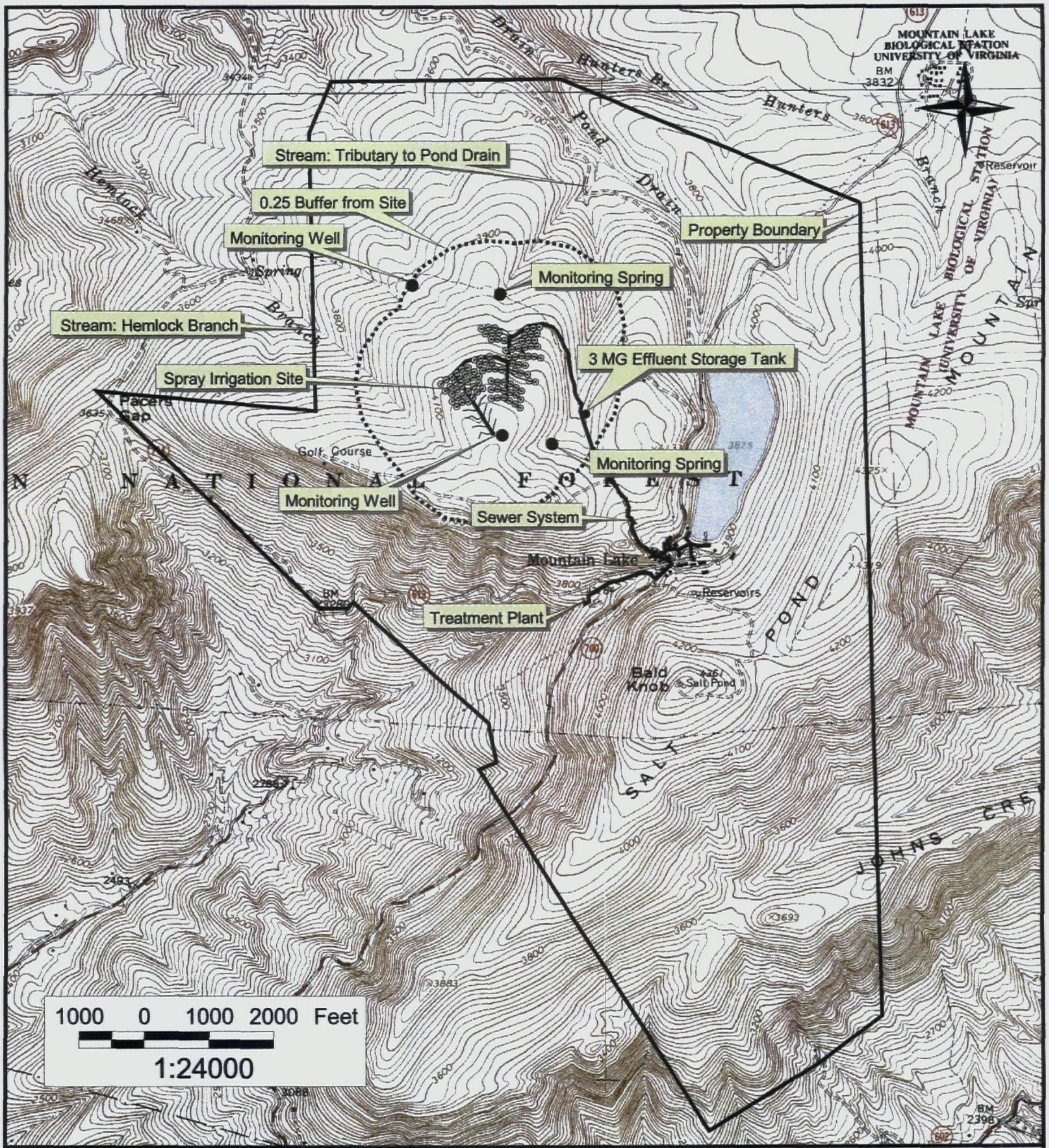
For waste to be land applied, the owner, as defined by 9 VAC 25-32, must sign the following statement.

I certify that the waste described in this application is non-hazardous and not regulated under the Resource Conservation and Recovery Act or the Virginia Hazardous Waste Management Regulation (9 VAC 20-60).

Betty Massey Date: 2/3/12
(Signature of Owner)

ATTACHMENT A

Detailed Location Map



Wastewater Treatment Facilities with Spray Irrigation
Mountain Lake, Virginia

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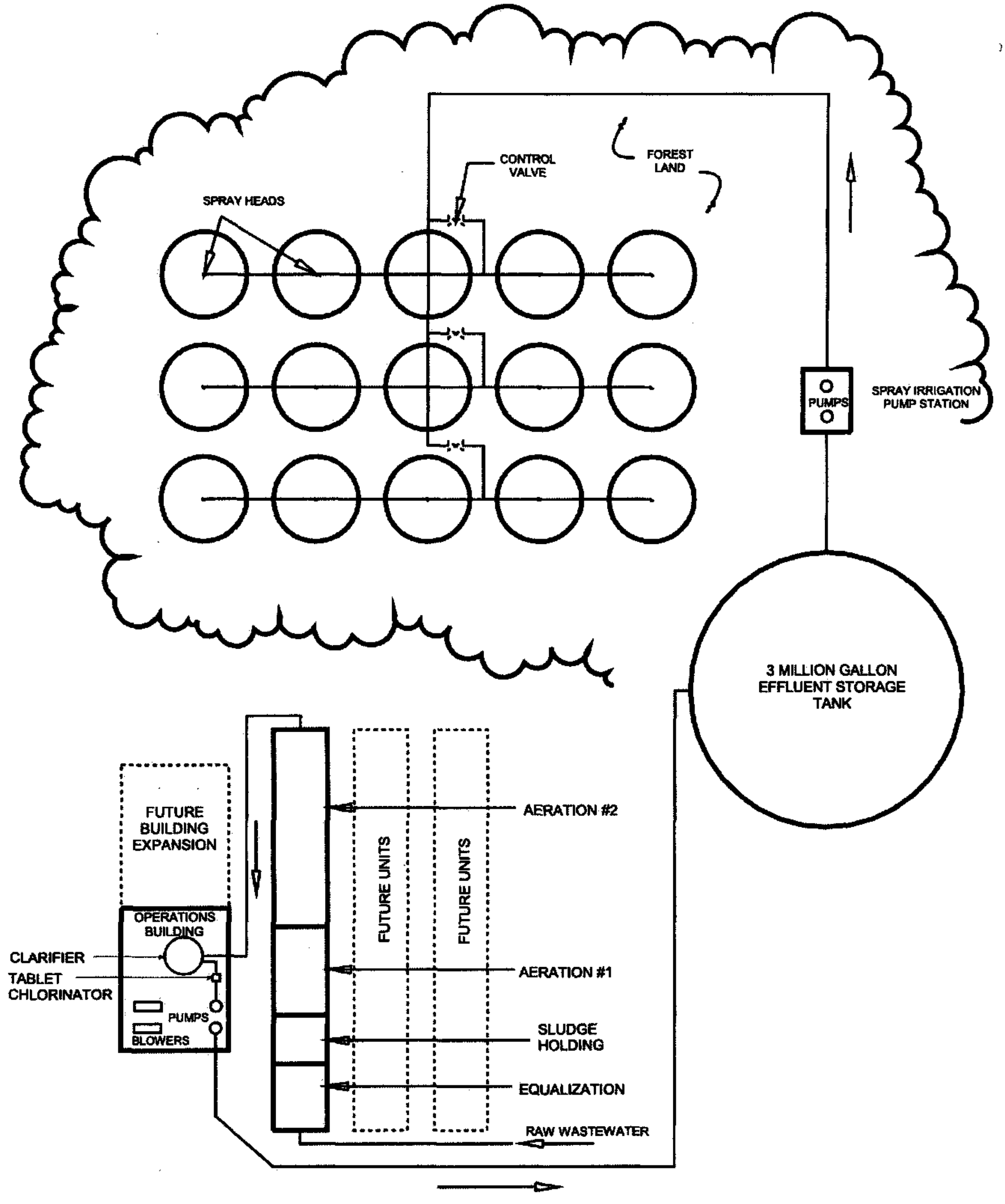
MOUNTAIN LAKE

ATTACHMENT B

Schematic Layout of Treatment and Disposal Facilities



Schematic for Layout of Wastewater Treatment System
Mountain Lake, Virginia

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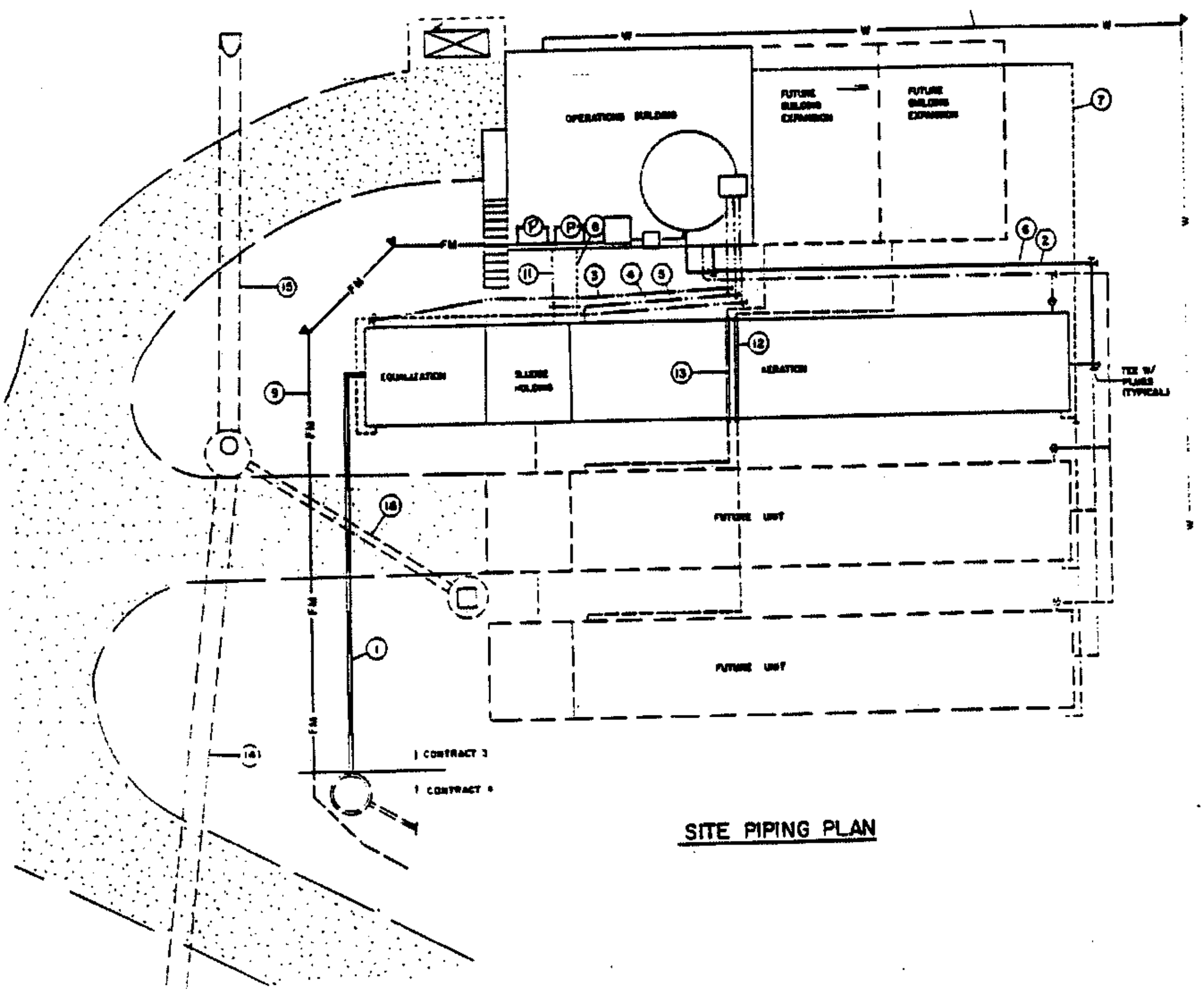
PIPING LEGEND

- INFLUENT SEWER
- MIXED LIQUOR
- FM — FORCE MAIN
- W — POTABLE WATER
- NONPOTABLE WATER
- SLUDGE LINE
- LABORATORY DRAIN
- AIR LINE
- FUTURE LINES
- E — 2" ELECTRICAL CONDUIT
- STORM SEWER

SITE PIPING SCHEDULE

PIPE NO.	DESCRIPTION	SIZE (IN.)	LENGTH (FT.)	MATERIAL	REMARKS
1	INFLUENT SEWER	8"	52'	DIP	
2	AERATION EFFLUENT	6"	66'	DIP	
3	EQUALIZATION SLUDGE RETURN	4"	52'	DIP	SLOPE @ 1% MIN. FROM BLDG.
4	WASTE SLUDGE	4"	32'	DIP	SLOPE @ 1% MIN. FROM BLDG.
5	AERATION SLUDGE RETURN	4"	20'	DIP	SLOPE @ 1% MIN. FROM BLDG.
6	FROTH SPRAY LINE	2"	53'	DIP	MIN. 4' COVER
7	AERATION AIR LINE	2½"	85'	GALV.	
8	EQUALIZATION AIR LINE	2"	53'	GALV.	
9	EFFLUENT FORCE MAIN	6"	83'	DIP	MIN. 4' COVER
10	POTABLE WATER	2"	165'	PVC	MIN. 4' COVER
11	LABORATORY DRAIN	4"	6'	DIP	SLOPE @ 1% MIN. FROM BLDG.
12	SLUDGE RETURN	4"	-	DIP	THROUGH STP-PLUG FOR FUTURE CONNECTION
13	SLUDGE RETURN	4"	-	DIP	THROUGH STP-PLUG FOR FUTURE CONNECTION
14	STORM SEWER	30"	72'	CONC.	UPST. INV = 3752.0 DNST. INV = 3743.5
15	STORM SEWER	30"	81'	CONC.	UPST. INV = 3742.6 DNST. INV = 3738.0
16	STORM DRAIN	12"	34'	CONC.	UPST. INV = 3747.0 DNST. INV = 3745.0



SITE PIPING PLAN

Site Piping Schedule Mountain Lake, Virginia

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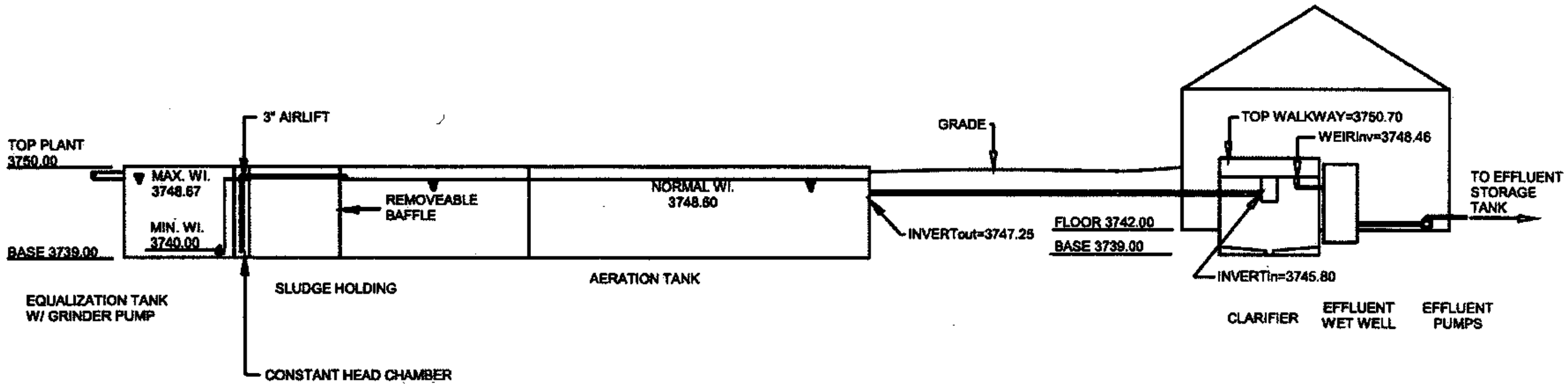

Hydraulic Profile Mountain Lake, Virginia

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MOUNTAIN LAKE

ATTACHMENT C

Design Basis for System Loading

Table 1. Original Design - Projected Wastewater Flows by Source at Full Occupancy

Source	Number	Rooms	Units	Unit Flow GPD/Unit	Ultimate GPD
Main Lodge	105	50	person	50	5250
Chestnut Lodge	34	16	person	50	1700
Cottages	105	50	person	50	5250
New Rooms	71	34	person	50	3550
Barn/Conf. Ctr.	250		person	5	1250
Employees	100		person	15	1500
Employees (Live in)	10		person	50	500
Employees, New	20		person	15	300
Dining Room	125		seat	50	6250
Dining Room Addition	50		seat	50	2500
Laundry	16		hours	50	800
Laundry (Addit. Use)	16		hours	50	800
Health/Sports Complex			lump sum		1850
Total					31500
Full Occupancy					315
Per Capita Flow (gpcd)					100

Note: Estimated 2.1 persons/room.

Table 2. Original Design - Projected Monthly Occupancy and Wastewater Flows

Month	Occupancy	Ultimate Flow GPD
Jan	214	21400
Feb	214	21400
Mar	164	16400
Apr	185	18500
May	195	19500
Jun	255	25500
Jul	315	31500
Aug	315	31500
Sep	235	23500
Oct	267	26700
Nov	206	20600
Dec	267	26700
Minimum	164	16400
Average	236	23600
Maximum	315	31500
GPCD		100

Table 3. Flow Rates at treatment Facility - 2010-2011

Month	Year	Reported Flow GPD	Original Design Flow GPD
September	2010	4,100	23,500
October	2010	7,600	26,700
November	2010	9,700	20,600
December	2010	7,100	26,700
January	2011	4,100	21,400
February	2011	8,300	21,400
March	2011	11,300	16,400
April	2011	11,400	18,500
May	2011	12,700	19,500
June	2011	8,200	25,500
July	2011	8,200	31,500
August	2011	10,200	31,500
Minimum		4,100	16,400
Average		8,600	23,600
Maximum		12,700	31,500

Table 4. Original Design Organic Load by Source at Full Occupancy

SOURCE	NUMBER	UNITS	BOD5 & TSS/UNIT LB./DAY/UNIT	DESIGN LOAD LB./DAY
Main Lodge	105*	person	.13	13.7
Chestnut Lodge	34*	person	.13	4.4
Cottages	105*	person	.13	13.7
New Rooms	71*	person	.13	9.2
Barn/Conf. Ctr.	250	person	incl.**	
Employees	100	person	incl.**	
Employees (Live in)	10	person	.20	2.0
Employees, New	20	person	incl.**	
Dining Room	125	seat	.20	25.0
Dining Room Addition	50	seat	.20	10.0
Laundry	2	machines	.30	.0
Laundry (Addit. Use)				
Health/Sports Complex		lump sum	3.7	3.7
Health Club (Addit. Use)		lump sum	7.0	7.0
Total BOD5 & TSS Load (lb./day)				89.3
Design Flowrate gpd				35,000
Concentration (mg/l)				306

*Number of guests is estimated using 2.1 persons/room.
**Values that are typically included in per capita rate assigned to guests.

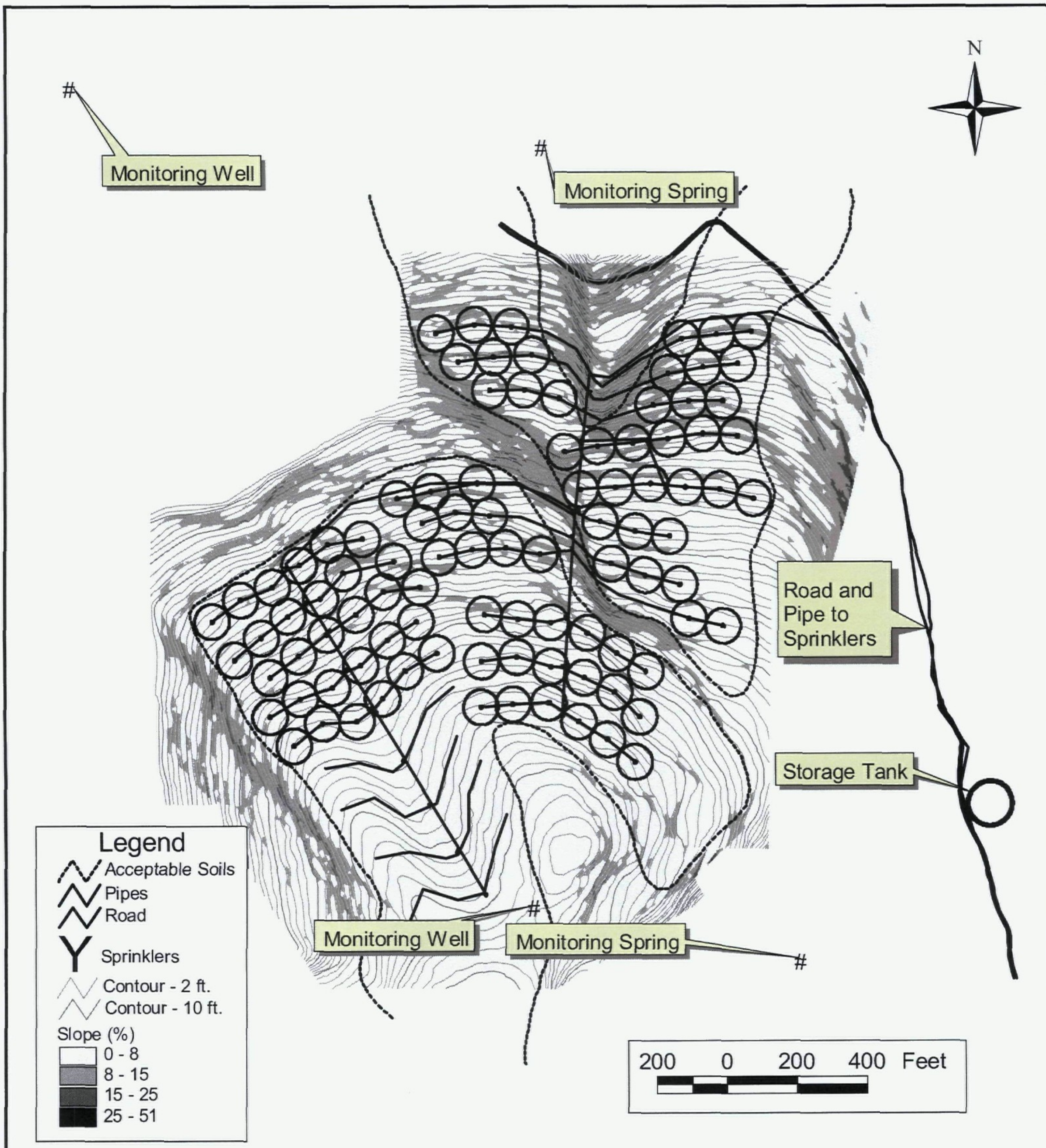
Table 5. Originally Anticipated Wastewater Characteristics

PARAMETER	NO. SAMPLES	SOURCE	RANGE mg/l	CONC. mg/l	LOADING lb/day*
BOD5		computed		306	89.3
BOD5	2	measured	168-241	205	59.8
TSS		computed		306	89.3
TSS	2	measured	95-220	158	46.1
Total Solids	2	measured	306-425	366	106.4
Volatile Solids	3	measured	154-389	248	72.4
Total Nitrogen		computed	11-41	25	10.5
Kjeldahl N	3	measures	10.7-39.0	25	7.3
NH3/NH4-N	2	measured	2.1-18.7	10	2.9
NO2-N	1	measured		0.004	
NO3-N	1	measured		0.077	
NO2+NO3	2	measured	0.10-1.96	1.03	0.03
Total P	3	measured	5.0-8.2	6.2	1.8
Ortho P	2	measured	1/7-4.8	3.2	0.9
Alkalinity	1	measured		98.6	28.8
Conductivity	1	measured	umho/cm	365	
pH	3	measured	6.7-8.1 su.	7.2	
Arsenic	1	measured		0.005	0.001
Boron	1	measured		0.18	0.05
Calcium	1	measured		12.6	3.68
Cadmium	1	measured		<.006	0.00
Copper	1	measured		0.05	0.01
Chlorides	1	measured		47.04	13.73
Lead	1	measured		0.30	0.08
Magnesium	1	measured		1.8	0.52
Nickel	1	measured		<0.2	<0.05
Potassium	1	measured		21.9	6.39
Sodium	1	measured		78.9	23.03
Sulfates	2	measured	12-21.1	16.5	4.81
Zinc	1	measured		0.04	0.01
COD	3	measured	396-450	429	125.2

*Loading rates are based on a daily flowrate of 35,000 gpd.

ATTACHMENT D

General Site Layout



Site Plan of Spray Irrigation Mountain Lake, Virginia

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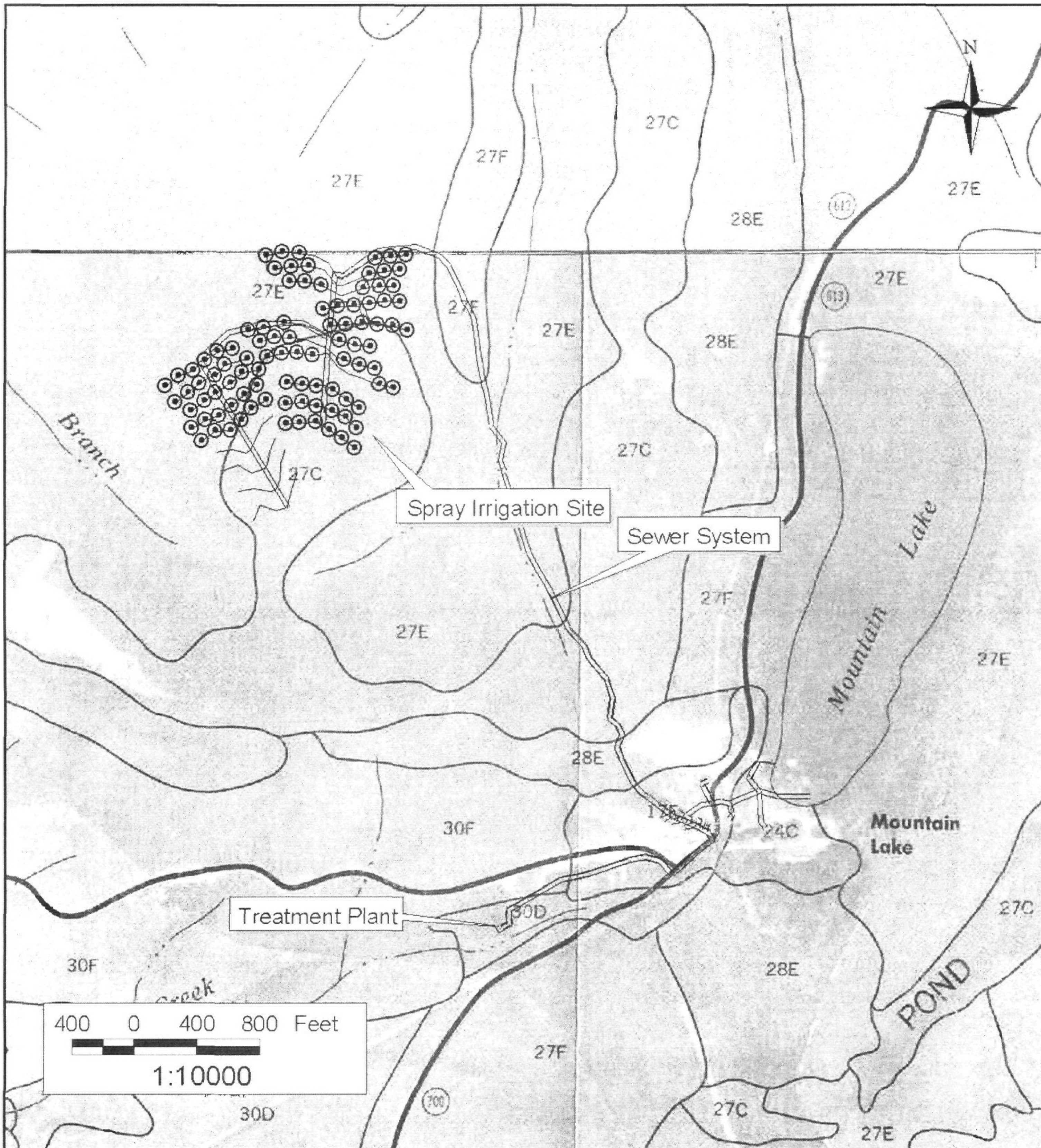
MOUNTAIN LAKE

ATTACHMENT E

Detailed Soil Survey Map



USDA-SCS Soil Survey Map
Mountain Lake, Virginia

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MOUNTAIN LAKE

ATTACHMENT F

Spray Irrigation Site Soil Sample Information

SOIL EVALUATION REPORT
PROFILE DESCRIPTIONS

HEALTH DEPARTMENT
IDENTIFICATION NO. ____________

PAGE ______ OF ______

MATHEWS SOIL CONSULTANTS INC.

The location of soil evaluation profile holes is shown on the schematic drawing or site plan which accompanies this report. The site sketch includes the estimated or measured location of all known wells, sewage disposal systems, springs, and structural features within 100 feet of the proposed drainfield and/or reserve drainfield site.

HORIZON	DEPTH INCHES	DESCRIPTION OF COLOR, TEXTURE, ETC.	TEXTURE GROUP
SOIL DOCUMENTATION		MOUNTAIN LAKE PROPERTY GILES COUNTY, VIRGINIA	
HOLE #1			
A	0-5	brown to dark brown; very friable; very fine sandy loam	II
B21	5-18	brown; friable; loam	II
B22	18-38	strong brown mottled with yellowish-brown and pale yellow; friable; clay loam which is slightly compact in place; few gravel	III
Bg	38-75+	gray mottled with pinkish-gray; firm; clay to silty clay with about 5% stone fragments; chroma 2 colors start at about 35 to 38"	IV
HOLE #2			
A	0-5	dark reddish-brown to dusky red; very friable; loam with a few gravel fragments	II
B21	5-18	dark reddish-brown; very friable; clay loam with a few gravel fragments	
B22	18-40	dusky red mottled with yellowish-brown, pinkish-gray and gray; friable; clay loam grading to clay	II/IV
Bg	40-78	gray mottled with weak red, yellowish-brown, pinkish-gray and strong brown; firm; clay to silty clay; contains a few rock fragments; difficult to dig at 78"; chroma 2 colors start between 24 and 36"	IV
HOLE #3			
A	0-8	dark reddish-brown; very friable; loam with noticable organic matter; contains as much as 70% stone fragments	II
B	8-64	grayish-brown; friable to very friable; loam containing 50 to 55% stone fragments; stone fragments range from 1" to 1½' along the long dimension and consist of dark colored fine grained sandstone	II
HOLE #4			
A	0-5	dark reddish-brown 5YR 3/2; very friable; sandy loam to loam with about 20% stone fragments	II
B21	5-75	dark reddish-brown 2.5YR 3/4; friable; loam to clay loam	III
B22	75-125+	red to dark reddish-brown; friable; clay loam with a noticable increase in sand content with depth; contains about 10% stone fragments ranging from 1" to 1' in diameter stone fragments are 1 to 3" thick sandstone fragments;	III

HOLE #5			
A	0-6	very dark grayish-brown; very friable; sandy loam to loam containing about 70% stone fragments	II
B	6-55	dark reddish-brown; very friable; heavy sandy clay loam to clay loam	II/III
B3/Bg	55-85	weak red 10R 7/3 mottled with pale yellow and gray; friable; heavy clay loam to light clay; the profile contains about 25% stone fragments below 10" in depth; the bottom of the hole is approaching hard rock; chroma 2 colors start at about 55"	III
HOLE #6			
A/B21	0-18	dark yellowish-brown; very friable; sandy loam to loam	II
B22	18-60	mottled weak red, pinkish-gray and yellowish-brown; friable to firm; clay loam which grades to clay; chroma 2 colors start at about 18" and increase in intensity with depth; clay content also increases with depth; contains 5 to 15% rock fragments which consist of gray sandstones	III
HOLE #7			
A	0-6	dark grayish-brown; very friable; sandy loam to loam	II
B2	6-24	dark yellowish-brown; very friable to friable; loam to clay loam	III
C/R	24-36	dark yellowish-brown grading to weak red mottled with gray; chromas are predominately 3 and 4 with gray chroma 2 inclusions; this material is about 50% rock fragments with light clay loam soil material intermixed within and between the fragments; chroma 2 mottles start at about 24"	III
HOLE #8			
A	0-4	very dark grayish-brown; very friable; sandy loam to loam	II
B	4-40	dark reddish-brown; very friable; very gravelly to cobbley; sandy clay loam; gravel content makes up 30 to 70% of the soil profile; gravel and stone content increases with depth rock material consist of very dark reddish-brown, hematite sandstone; it occurs mostly as flat pieces, one inch to 1½ inches in thickness ranging from ½ inch in diameter to as much as a foot in diameter	II
R	40	hole terminated on bedrock	
HOLE #9			
A	0-5	very dark grayish-brown; very friable; gravelly loam	II
B	5-60	dark reddish-brown; friable; loam to clay loam containing 40 to 50% gravel, cobbles and stones; rock fragments are from the hematite sandstone and range in size from one milimeter to two feet in diameter	III
HOLE #10			
A	0-5	very dark grayish-brown; very gravelly and cobbley; loam	II
B	5-32	dark reddish-brown; cobbley, gravelly and stoney; clay loam	III
R	32	tightly bedded hematite sandstone	
HOLE #11			
A	0-12 to 0-24	2.5YR 3/2 dusky red; very friable to loose; loam; very gravelly and cobbley; stone fragments make up more than	

		90% of this horizon	II
B21	24-32	dark red 2.5YR 3/6; friable; loam to light clay loam containing approximately 50% stone fragments; ranges from 24 to about 32" in depth	III
B22	32-72+	dark reddish-brown 2.5YR 3/4; friable to very friable; light clay loam containing 50 to 60% hematite sandstone fragments; this hole was left open for future observation	III
HOLE #12			
A	0-6	dark grayish-brown to dark reddish-brown; very friable; gravelly and cobbley; loam; coarse fragments make up about 30% of this horizon	II
B2	6-45	dark reddish-brown; friable; clay loam containing 40 to 50% coarse fragments which range in size to cobbles	II
C	45-52	weak red to dark reddish-brown; hematite sandstone which is difficult to dig with a backhoe	n/a
R		bedrock	N/A
HOLE #13			
A	0-6	very dark reddish-brown; very friable; loam with about 15% coarse fragments	II
B2	6-50	dark reddish-brown; friable; clay loam containing about 15% coarse fragments	III
B22	50-87	dark red to dark reddish-brown; friable; clay loam to light clay; this profile contains about 15% coarse fragment which range from 1/4" to 6 or 8 inches in diameter; they are flat ½" to 1" thick fragments of hematite sandstone	III/IV
HOLE #14			
A	0-10	very dark grayish-brown; very friable; gravelly loam	II
B21	10-36	dark reddish-brown; friable; clay loam containing about 15% sandstone fragments	III
B22	36-84+	dark red; friable; clay containing about 15% hematite sandstone fragments	III/IV
HOLE #15			
A	0-8	very dark grayish-brown to very dark reddish-brown; very friable; gravelly loam	II
B21	8-28	dark reddish-brown; friable; clay loam containing about 20% coarse fragments	
B22	28-67	dark red; friable; light clay containing about 15% sandstone fragments	III/IV
HOLE #16			
A	0-5	very dark grayish-brown; very friable; loam	II
B	5-30	dark yellowish-brown; very friable to friable; clay loam; this profile contains about 30% coarse stone fragments ranging from 6" to 4' in diameter	III
R	30	bedrock or large stone fragments	
HOLE #17			
A	0-5	very dark gray 5YR 3/2 dark reddish-brown 5YR 3/2; very friable; loam; contains numberous rock fragments	II
B21	5-30	strong brown 7.5YR 4/6; friable; loam to clay loam	II/III
B22	30-72	weak red 10R 4/3; firm; clay loam to clay with strong medium angular and subangular blocky structure; this profiles contains 5 to 20% sandstone fragments throughout; fragments range from 1/4" to 3' in diameter; no chroma 2 colors noted; the sandstone material is easily cut with a	

		backhoe and leaves a pale color	III/IV
HOLE #18			
A	0-5	dark reddish-brown 5YR 2.5/2; very friable; loam	II
B21	5-20	reddish-brown 5YR 4/3; friable; clay loam; containing about 30 to 45% coarse fragments ranging from less than 1/4" to about 3"	III
B22	20-75	weak red 10R 4/3; friable; light clay loam containing about 45% coarse fragments which range from 1/4" to 5" in diameter; no chroma 2 colors	III
HOLE #19			
A	0-5	dusky red 2.5YR 3/2; very friable; sandy loam to loam	II
B21	5-36	dark reddish-brown 2.5YR 3/4; friable; sandy clay loam to light clay loam	II/III
B22	36-78+	dark red 2.5YR 3/6; friable; clay loam which grades to clay below about 60"; this horizon contains about 10% highly weathered sandstone fragments which are easily cut with a backhoe bucket; the horizons above contain less than 5% sandstone fragments; no chroma 2 colors noted; some dark reddish-brown iron fragments as small as 1/2" were observed	III/IV
HOLE #20			
A	0-5	dusky red 2.5YR 3/2; very friable; sandy loam to loam; contains a concentration of sandstone fragments near the surface	II
B21	5-53	dark reddish-brown 2.5YR 3/4; friable; clay loam with about 5% standstone fragments	
B22	53-65	yellowish-red mottled with red; friable to slightly plastic clay; the boundary between the B21 and B22 is abrupt; this contains numerous, very weathered sandstone fragments which are easily cut with a backhoe bucket; no chroma 2 mottles noted	IV
HOLE #21			
A	0-5	dusky red 2.5YR 3/2; very friable; sandy loam to loam	II
B21	5-50	dark reddish-brown 2.5YR3/4; friable; clay loam	III
B22	50-65+	reddish-brown to yellowish-red; friable to firm; clay loam to clay; this profile contains 5 to 25% sandstone fragments throughout; fragments range in size from 1 or 2" to 2½'; there is a concentration of sandstone fragments near the surface; no chroma 2 colors noted	III/IV
HOLE #22			
A	0-5	dusky red 2.5YR 3/2; very friable; sandy loam to loam	II
B21	5-40	dark reddish-brown 2.5YR 3/4; friable; clay loam with a few sandstone fragments	III
B22	40-80	dark reddish-brown 2.5YR 3/4; friable; heavy clay loam to clay containing about 15% sandstone fragments ranging from 1/4" to 1' in diameter	III/IV
B23	80-110+	strong brown; friable; light clay to heavy clay loam containing numerous sandstone fragments ranging from 1" to 2½'; sandstone fragments throughout the profile represent about 10 to 15% by volume; large fragments in the lower profile below 90" represent about 25% by volume; no chroma 2 mottles noted; no free water	IV
HOLE #23			
[illegible]	0-5	dusky red 2.5YR 3/2; very friable; sandy loam to loam	

		containing numerous large sandstone fragments	II
B21	5-30	dark reddish-brown 2.5YR 3/4; friable; clay loam with a few sandstone fragments ranging from 1/4" to 6" in diameter	III
B22	3 90	dark reddish-brown 2.5YR 3/4; friable to firm; heavy clay loam to light clay containing about 15% sandstone fragments which range from 1/4" to 5" in the long dimension; no chroma 2 colors	III/IV
HOLE #24			
A	0-8	dusky red 2.5YR 3/2; very friable; sandy loam to loam containing 30 to 40% hematite sandstone fragments ranging from 1/4" to 2'	II
B2	8-60	dark reddish-brown 2.5YR 3/4; friable; loam to clay loam containing 40 to 55% sandstone fragments ranging from ½" to 2'; sandstone fragments are thinly bedded with a thickness of 1 to 2 inches; they occur in the profile approximately parallel to the land surface and they appear to be randomly oriented indicating colluviation; no chroma 2 colors	III
R	60	bedrock or dense colluvial sandstone	N/A
HOLE #25			
A	0-5	dusky red 2.5YR 3/2; very friable; sandy loam to loam	II
B21	5-63	dark reddish-brown 2.5YR 3/4; friable; clay loam containing 40 to 60% sandstone; difficult to dig below 50"; some worm cast patterns were noted on the deepest rock pulled from the pit	III
R	63	rock	n/a
HOLE #26			
A	0-6	dusky red 2.5YR 3/2; very friable; sandy loam to loam	II
B21	6-45	dark reddish-brown 2.5YR 3/4; friable; clay loam	III
B3	45-58	dark reddish-brown; friable; clay loam containing 50 to 70% flatley bedded hematite sandstone fragments; rock increases in percentage with depth	III
R	58	bedrock which can still be scratched and dug with a backhoe with difficulty	n/a
HOLE #27			
A	0-4	very dusky red 2.5YR 2.5/2; very friable; loam contains 10% sandstone fragments	II
B1	4-14	dark reddish-brown 2.5YR 3/4; very friable to friable; loam	II
B2	14-42	dark red 2.5YR 3/6; friable; clay loam slightly sticky when wet; contains about 5% sandstone fragments	III
B3	42-50	dark reddish-brown 2.5YR 3/4; friable; clay loam containing about 30% red hematite sandstone fragments	III
	50	bedrock	n/a
HOLE #28			
A	0-7	dusky red 2.5YR 3/2; very friable; loam containing 15% sandstone fragments	II
B2	7-34	dark reddish-brown 2.5YR 3/4; friable; clay loam containing 20% sandstone fragments	III
R	34	bedrock; large flatly bedded hematite sandstone fragments	
HOLE #29			
	0-5	dusky red 2.5YR 3/2; very friable; loam containing about 30% hematite sandstone fragments	II

B	5-38	dark reddish-brown 2.5YR 3/4; friable; clay loam; sandstone fragments start off as about 20% and gradually increase to about 80% of the matrix	III
R	38	rock	n/a
HOLE #30			
A	0-5	dusky red 2.5YR 3/2; very friable; loam containing about 30% hematite sandstone fragments	II
B	5-38	dark reddish-brown 2.5YR 3/4; friable; clay loam; sandstone fragments start off as about 20% and gradually increase to about 80% of the matrix	III
R	38	rock	n/a
HOLE #31			
A	0-6	weak red; very gravelly and stoney; loam; gravel content makes up 80 to 95% of this horizon; the A horizon has a gradual wavey boundry with thickness of the A ranging from about 6" to 20 inches	N/A
B	6-36+	dark reddish-brown to yellowish-red; friable; loam to light clay loam containing about 25% hematite sandstone fragments	II/III
R	38+	hole terminated on hematite sandstone	
HOLE #32			
A	0-5	dark grayish-brown; very friable; gravelly loam; gravel content is 5 to 15%	II
B21	5-32	dark brown to dark reddish-brown; very friable; gravelly loam; gravel content is 10 to 20%	II
B22	32-48+	mottled weak red, yellowish-brown, strong brown and gray; friable; silty clay to clay loam containing 15 to 20% sandstone fragments	III/IV
R	50	hole terminated; chroma 2 colors start at 32 ± " and become more abundant and intense with depth	N/A
HOLE #33			
A	0-5	dark grayish-brown which quickly grades to dark reddish-brown; very friable; gravelly loam; gravel content is about 10 to 15%	II
B21	5-30	dark reddish-brown; very friable; gravelly and cobbley; heavy loam to light clay loam; rock fragments are hematite sandstones of various orientation; an estimate of the gravel and cobble sized fragments is 30% by volume	II/III
B3	30-42	dark reddish-brown; friable; clay loam grading to dark red friable; clay; the heavier texture material occurs between stone fragments at the bottom of the pit; fragment orientation varies from horizontal to vertical; fragment size has increased to be greater than 4" but less than about 12" and fragment content has increased to 60 or 70%; it looks to be fairly uniformed within the pit with normal distribution of large and small fragments	II/IV
R	42	pit terminated on apparent hard rock which is bedded horizontal to the land surface	N/A
HOLE #34			
A	0-7	dark grayish-brown which quickly grades to dark reddish-brown; very friable; gravelly loam	II
B21	7-42	dark reddish-brown; gravelly clay loam which has moderate to strong fine and very fine subangular blocky structure;	

		gravel ranges in size from less than 1/4" to a maximum of 2 or 2 1/2"; predominately the gravel content is in the 1/4 to 1 1/2" size and the content varies from about 10 or 15% up to 35 or 40%	II
B22	42-75+	dark red to dark reddish-brown; friable; clay with moderate to strong fine subangular blocky structure; gravel content is 33% and the size of the fragments has increased to reach as much as 6" in the long dimension; there is no evidence of water table problems; the hole was terminated because of depth and not because of stoniness	IV
HOLE #35			
A/B1	0-8	dark grayish-brown which quickly grades to dark reddish-brown; very friable; gravelly loam	II
B2	8-36	dark reddish-brown; very friable to friable; loam to light clay loam which contains 40 to 55% hematite sandstone fragments ranging in size from 1/4" to about 6"	II/III
B3	36-45+	dark reddish-brown to weak red; friable; loam to clay loam containing 50 to 70% hematite sandstone fragments or varing orientations; near the bottom of the pit, there are some pale yellow to gray clay flows between rock and stone fragments; these occur at about 45" and they are clay in texture	II/III
R	45	hole terminated on apparent hard rock which is horizontally bedded	
HOLE #36			
A/B1	0-8	dark grayish-brown which quickly grades to dark reddish-brown; very friable; loam with about 5 to 10% small gravel	II
B21	8-30	dark reddish-brown; very friable; heavy loam to light clay loam containing about 10% sandstone fragments	II/III
B22	30-75+	dark red to dark reddish-brown; friable to very friable; clay loam containing about 15% sandstone fragments; fragments in this profile range from about 1/4 to 4 or 5" and are distributed fairly uniformily throughout the profile; this hole contains about 3" of water in the bottom of the pit (24 hours after digging) and it was terminated on apparent hard rock	III
HOLE #37			
A/B1	0-8	dark grayish-brown quickly grading to dark reddish-brown; very friable; gravelly loam	II
B21	8-30	dark reddish-brown; very friable; light clay loam containing about 15 to 20% hematite sandstone fragments which range from 1/4 to 4" in diameter	
B22	30-52	dark reddish-brown; friable to very friable; clay loam containing about 30 to 35% hematite sandstone fragments which range from 1/2 to 5" in diameter; in general, fragments increase in size and intensity with depth; they are of varying orientation indicating that there has been some transportation movement	III
	52	hole terminated on flat bedded hematite sandstone which contains loam to clay loam soil material between the sandstone fragments	N/A
HOLE #38			
A/B1	0-7	weak red grading to dark reddish-brown; very friable; loam	

		containing 25 to 35% hematite sandstone fragments which range to 5" in size	II
2	7-30	dark reddish-brown; friable to very friable; light clay loam which has moderate to strong fine and very fine subangular blocky to granular structure; this horizon contains about 20 to 25% sandstone fragments which range from 1/2 to 5" in diameter	II/III
B22	30-47+	weak red; friable; light clay loam which contains 30 to 45% sandstone fragments of varying orientation; fragments range from ½" to more than 7"; weak red colors will probably reach chroma 2 on the color chart; however, no gray colors were observed	II/III
R	47	hole terminated on flatly bedded hematite sandstone; weak red chroma 2 colors observed at about 30"	
HOLE #39			
A/B1	0-14	dark grayish-brown which quickly grades to dark reddish-brown; very friable; loam containing about 10% gravel fragments	II
B21	14-38	weak red; gravelly to very gravelly; light clay loam; gravel content is about 35% and ranges in size from ½" to 6"; gravel fragments are well distributed and the weak red colors do not appear to be those which would go below chroma 3	III
B22	38-65+	dark red; friable; clay with strong fine and very fine subangular and angular blocky structure; contains 5 to 15% sandstone fragments; clay films on ped surfaces are thick and continuous	IV
	65	hole terminated on apparent hard sandstone which is bedded parallel to the land surface; sandstone pulled from the pit range to 2' in the long dimension and range from about ½" in thickness to 4"; sandstone is hematite; this hole contained about 2" of water in the bottom of the pit	N/A
HOLE #40			
A/B1	0-8	dark grayish-brown which quickly grades to dark reddish-brown; very friable; gravelly loam	II
B21	8-42	dark reddish-brown; gravelly to very gravelly; friable; clay loam; gravel content is probably 30 to 40% and consist primarily of samll gravels, 1/4 to 1" in size with a few fragments ranging to 4 or 5"	III
B22	42-57	dark reddish-brown grading to dark red; friable; clay mottled in places with ocre weathered rock; structure is moderate to strong fine and very fine subangular blocky with discontinuous clay films on ped surfaces; contains a few sandstone fragments which increase in number and density with depth	IV
R	57	hole terminated on hematite sandstone which is bedded parallel or approximately parallel to the land surface	n/a
HOLE #41			
A/B1	0-8	dark grayish-brown grading to dark reddish-brown; very friable; loam	II
B2	8-30	dark reddish-brown to yellowish-red; friable; gravelly clay loam to clay; gravel content is about 15%	III/IV
	30-35	yellowish-red to dark reddish-brown; very friable to	

		friable; clay to clay loam; occurs between flatly bedded sandstone fragments; sandstone fragments make up about 75% of this zone	III/IV
R	35	hole terminated on flatly bedded sandstone;the flatly bedded sandstone fragments have good soil development between the strata, with well defined wormcast and other animal burrows	N/A
HOLE #42			
A	0-6	dark grayish-brown which quickly grades to dark reddish-brown; very friable; gravelly loam	II
B21	6-36	dark reddish-brown; very friable to friable; gravelly loam to clay loam; gravel content is about 25% and consist primarily of small sandstone fragments ranging from 1/4 to 1" in size	II/III
B22	36-42	dark reddish-brown to strong brown; friable; heavy clay loam containing 30 to 50% sandstone fragments, some of which are oriented parallel to the soil surface; fragments tend to increase in size and abundance with depth	III
R	42	hole terminated on sandstone fragments which are bedded parallel to the land surface	
HOLE #43			
A/B1	0-20	dark grayish brown which quickly grades to dark reddish-brown; very friable; loam containing 10 to 15% sandstone fragments	II
B2	20-32	red to dark reddish-brown; very friable; heavy clay loam containing about 30% sandtstone fragments ranging from 1" to 5" in diameter	III
B3	32-42	red to dark red; friable; heavy clay loam which occurs in horizontal lenses between sandstone fragments; sandstone fragments make up 50 to 70% of the matrix; however, structural development and soil development is strong between fragments; fragments are oriented predominately parallel to the land surface	III
R	42	hole terminated on hard sandstone fragments which are difficult to dig with a backhoe; orientation of sandstone is paralell to the land surface	n/a
HOLE #44			
A/B1	0-12	dark to dark reddish-brown; very friable; gravelly loam	II
B2	12-32	dark reddish-brown; friable to very friable; gravelly clay loam; gravel content represents about 25 to 30% of the matrix and consist primarily of small fragments ranging from 1/4 to 3" in dimension	III
B3	32-45+	dark reddish-brown; friable; clay loam which occurs between parallel bedded hematite sandstone fragments and lenses; sandstone makes up 60 to 80% of the soil matrix and occurs as fragments bedded parallel to the land surface; some white and gray silty clay zones were noted on the backhoe pit pile but none observed when I dug the pit down; these apparently came from the bottom of the pit which may be as deep as 45"; these colors appear to fit within chroma 2 colorations; no water observed in the bottom of the pit	III
R	45	hole terminated on hard hematite sandstone bedded parallel to the land surface	n/a

HOLE #45

A/B1	0-10	dark grayish-brown which quickly grades to dark brown or dark reddish-brown; very friable; loam with a concentration of sandstone fragments within the first 3 to 4"	II
B2	10-42	dark reddish-brown; very friable; gravelly loam; sandstone fragments make up about 35% of the soil matrix; they are primarily in the size range of 3 to 6" and have variable orientation; near the bottom of the pit, they are oriented parallel to the land surface; there is some increase in sandstone fragments with depth particularly from about 36 to 42"	III
R	42	hole terminated on hard sandstone fragments oriented parallel to the land surface	n/a

HOLE #46

A/B1	0-12	dark grayish-brown which quickly grades to dark reddish-brown; very friable; gravelly loam; gravel content is approximately 30% of the matrix	II
B21	12-24	dark reddish-brown; very friable; light clay loam containing about 35% gravel fragments which range from 1/4 to 5"; fragments are oriented in all directions	III
B22	24-42	weak red mottled in the lower part with gray; friable; clay loam which contains 30 to 70% sandstone fragments; sandstone fragments increase in number and size with depth and below about 36", they are bedded parallel to the soil surface; chroma 2 colors start at about 30"	III
R	42	hole terminated on flat bedded hematite sandstone	n/a

HOLE #47

A	0-8	dark grayish-brown which quickly grades to dark reddish-brown; very friable; loam with gravel making up about 15% of the matrix	II
B21	8-30	dark reddish-brown; very friable; gravelly light clay loam; gravel are predominately 1/4 to 1" fragments of sandstone which make up about 20 to 25% of the matrix	III
IIB	30-72+	mottled weak red, olive gray, gray and reddish-brown; friable to firm; silty clay with occasional sandstone fragments; chroma 2 colors start at about 28 - 30" and are noted throughout the profile; they increase in intensity with depth; soil material below 30" is plastic	IV

GENERAL COMMENT: These soil profiles tend to increase in clay content with depth with higher clay content being observed between the sandstone fragments near the bottom of the pits. Typically a clay loam profile will be a heavy clay loam to a light clay at that depth.

REMARKS: Sandstone fragments associated with dark reddish-brown, red and dusky red soil colors are usually hematite rich.

NOTE: Holes #31 through #47 were described by visual inspection without the aid of a colorbook

HOLE #100			
A	0-3	black 10YR 2/1 friable; loam	II
Bhs	3-14	red 2.5YR 4/8; friable; loam	II
Bt	14-42	red 10R 3/6; friable; heavy loam to light clay loam;	II
2Bt	42-67	red 2.5YR 4/6; friable; light clay loam to a light sandy clay loam; 0-42" contains about 30% coarse fragments; 42-67" contains about 50% coarse fragments	II
HOLE #101			
A	0-3	black 10 YR 2/1; friable; loam	II
Bhs	3-13	red 2.5YR 4/6; friable; loam	II
BC	13-21	dark red 10R 3/6; friable; loam	II
B	21-38	dark red 2.5YR 3/6; friable; loam	II
R	38	hole terminated due to rock; 0-13" contains about 50% coarse fragments; 13-21" contains about 65% coarse fragments; and 21-38" contains about 70% coarse fragments	N/A
HOLE #102			
A	0-2	black 10YR 2/1; very friable; loam	II
Bhs1	2-9	dark red 2.5YR 2.5/4; friable; loam	II
Bhs2	9-21	red 2.5YR 4/6; friable; loam	II
BC	21-29	weak red 10R 4/4; friable; loam	II
C	29-47	weak red 10R 4/4;friable loam to silty clay loam;	II/III
C/Bt	47-75	dark red 2.5YR 3/4; friable; loam red 2.5YR 3/4 friable; heavy clay loam; 0-75" contains about 30% coarse fragments	II/III
HOLE #103			
A	0-3	black 10YR 2/1 very friable; loam	II
Bhs	3-13	dark reddish-brown 2.5YR 3/4; friable; loam	II
C	13-33	red 10R 3/4; friable; loam	II
2Bt	33-45	red 5YR 4/6; firm; heavy clay loam; 0-3" contains about 30% coarse fragments; 3-33" contains about 30% coarse fragments; and 33-45" contains about 15% coarse fragments	III
HOLE #104			
A	0-3	black 10YR 2/1; friable; loam	II
E	3-20	red 10R 3/3; friable; loam	II
Bhs	20-34	reddish-brown 2.5YR 4/4; friable; loam	II
E	34-43	reddish-brown 5YR 4/3; friable; loam; 0-43" contains about 80-90% coarse fragments	II
HOLE #105			
A	0-4	black 10YR 2/1; friable; loam	II
Bhs	4-18	dusky red 10R 3/4; friable; loam	II
Bt	18-30	dark red 10R 3/6; very friable; loam to light clay loam	II/III
BC	30-44	dark red 10R 3/6; friable; loam to light clay loam; 0-18" contains about 25% coarse fragments; 18-30" contains about 20% coarse fragments; 30-44" contains about 25% coarse fragments	II/III
HOLE #106			
A	0-5	black 10YR 2/1; very friable; loam	II
Bhs	5-21	dusky red 10R 3/4; friable; loam	II
Bt1	21-34	dark reddish-brown 2.5YR 3/4; friable; loam	II

Bt2	34-46	dusky red 10R 3/3; friable light clay loam; 0-21" contains about 17% coarse fragments; 21-34" contains about 10% coarse fragments; 34-46" contains about 25% coarse fragments with many fragments from 36-39"	III
HOLE #107			
	0-4	black 10YR 2/1; very friable; loam	II
Bhs	4-16	dark reddish-brown 2.5YR 3/4; very friable; loam	II
BC	16-30	reddish-brown 2.5YR 4/4; friable; loam	II
C	30-51	reddish-brown 2.5YR 4/4; friable; loam	II
2Btb	51-78	red 2.5YR 4/6; heavy silty clay loam; 0-16" contains about 50% coarse fragments; 16-30" contains about 75% coarse fragments; 30-51" contains about 55% coarse fragments; and 51-78" contains about 20% coarse fragments	III
HOLE #108			
A	0-3	black 10YR 2/1; very friable; loam	II
B	3-8	dark reddish-brown 2.5YR 2.5/4; very friable; loam	II
Bhs	8-24	yellowish-brown 5YR 2/6; friable; loam	II
BC	24-49	yellowish-brown 5YR 4/6; friable; loam	II
2Bt	49-74	dark red 2.5YR 3/6; friable light clay loam; 0-18" contains about 60% coarse fragments; 18-49" contains about 75% coarse fragments; and 49-74" contains about 50% coarse fragment	III
HOLE #109			
A	0-2	black 10YR 2/1; very friable; loam	II
Bhs	2-20	red 2.5YR 3/6; friable; loam	II
B	20-60	dark reddish-brown 2.5YR 3/4; friable; light clay loam 0-17" contains about 20% coarse fragments; and 17-60" contains about 70% coarse fragments	III
HOLE #110			
	0-3	black 10YR 2/1; very friable; loam	II
Bhs	3-20	dark reddish-brown 2.5YR 2.5/4; very friable; loam	II
Bt1	20-38	dark reddish-brown 2.5YR 2.5/4; friable; light clay loam	III
Bt2	38-48	dark red 2.5YR 3/6; friable; clay loam	III
2EB	48-55	dark reddish-brown 2.5YR 2.5/4; friable; clay loam	III
2Bt	55-65	dark reddish-brown 2.5YR 2.5 /4; friable; clay; 0-25" contains about 15% coarse fragments; 25-52" contains about 25% coarse fragments; and 55" is weathered rock	IV
HOLE #111			
A	0-4	black 10YR 2/1; very friable; loam	II
Bhs	4-19	dark reddish-brown 2.5YR 2.5/4; very friable; loam	II
C	19-33	dark reddish-brown 2.5YR 3/4; friable; loam	II
2Bt	33-55	dark red 10R 3/6; friable; clay loam	III
2Bt	55-75	dark red 2.5YR 3/6; friable; heavy clay loam; 0-32" contains about 15% coarse fragments; and 32-75" contains about 10% coarse fragments	III
HOLE #112		(OLD HOLE #38)	
A	0-4	black 10YR 2/1; very friable; loam	II
Bhs	4-20	dark reddish-brown 2.5YR 2.5/4; very friable; loam	II
Bt	20-45	dusky red 10R 3/3; friable; clay loam	III
2Bt	45-57	red 10R 3/4; friable; heavy clay loam	II

2Btb2	57-65	dusky red 10R 3/4; friable; clay loam; 0-25" contains about 20% coarse fragments; 25-52" contains about 25% coarse fragments; and 52-65" contains about 50% coarse fragments	III
HOLE #113			
A	0-2	black 10YR 2/1; very friable; loam	II
Bhs	2-20	dusky red 10R 3/4; very friable; loam	II
Bt	20-37	dark reddish-brown 2.5YR 3/4; friable; loam	II
BC	37-48	dusky red 10R 3/4; friable; clay loam; 0-48" contains about 20% coarse fragments	III
HOLE #114			
A	0-6	black 10YR 2/1; very friable; loam	II
Bhs	6-16	dark reddish-brown 2.5YR 3/4; very friable; loam	II
Bt	16-34	dusky red 10R 3/4; friable; light clay loam	III
BC	34-50	dusky red 10R 3/3; light clay loam; friable	III
2Bt	50-58	dusky red 10R 3/4; friable; clay loam	III
2Bt	58-70	dark reddish-brown 2.5YR 2.5/4; friable; heavy clay loam; 0-21" contains about 10% coarse fragments; 21-44" contains about 15% coarse fragments; 44-60" contins about 20% coarse fragments; and 60-70" contains about 25% coarse fragments	III
HOLE #115			
A	0-3	black 10YR 2/1; friable; loam	II
Bhs	3-19	dark red 2.5YR 3/6; friable; loam	II
BC	19-25	reddish-brown 2.5YR 4/4; friable; loam	II
B2	25-43	reddish-brown 2.5YR 4/4; friable; loam	II
BC	43-50+	reddish-yellow 7.5YR 6/8; silty clay; friable; 0-43" contains about 40% coarse fragments; and 43+" contains about 10% coarse fragments	IV
HOLE #116			
A	0-2	black 10YR 2/1; very friable; loam	II
Bhs	2-22	dark red 2.5YR 3/6; very friable; loam	II
Bt	22-36	dark red 2.5YR 3/6; friable; light clay loam	III
R	36	Hole terminated on rock or rock fragments; 0-6" contains about 90% coarse fragments; and 7-36" contains about 60% coarse fragments	
N/A			
HOLE #117			
A	0-3	black 10YR 2/1; very friable; loam	II
Bhs	3-21	dusky red; very friable; loam	II
B	21-27	dusky red; friable; light clay loam	III
Cr	27-35	dusky red; friable; loam; 0-6" contains about 60% coarse fragments; 6-27" contains about 60% coarse fragments; and 27-35" contains about 95% coarse fragments	II
R	35	hole terminated because of rock	N/A
HOLE #118			
A	0-4	black 10YR 2/1; very friable; loam	II
Bhs	4-19	dusky red 10R 3/4; very friable; loam	II
BC	19-41	dusky red 10R 3/4; friable; clay loam; 0-6" contains about 85% coarse fragments; and 6-41" contains about 30% coarse fragments	III
HOLE #119			

A	0-4	black 10YR 2/1; very friable; loam	II
Bhs	4-29	dark reddish-brown; friable; loam	II
BC	29-42	dark reddish-brown; friable; light clay loam; 0-28" contains about 40% coarse fragments; and 28-42" contains about 70% coarse fragments	III
HOLE #120			
A	0-3	black 10YR 2/1; very friable; loam	II
Bhs	3-28	dark reddish-brown 2.5YR 3/4; very friable; loam	II
BC	28-42	dark reddish-brown; 2.5YR 3/4; very friable; clay loam	III
C	42-48+	white 7.5YR 8/0; friable; clay; 0-15" contains about 80% coarse fragments; and 15-42" contains about 20% coarse fragments; very heavy clay	IV
HOLE #121			
A	0-3	black 10YR 2/1; very friable; loam	II
Bhs	3-16	dark reddish-brown 2.5YR 3/4; very friable; loam	II
Bt	16-32	dark reddish-brown 2.5YR 3/4; light clay loam	III
C1	32-44	dark reddish-brown 2.5YR 3/4; friable; clay loam	III
C2	44-54	dark reddish-brown 2.5YR 3/4; friable; clay loam	III
R	54	Hole terminated on rock or rock fragments; 0-32" contains about 50% coarse fragments; 32-44" contains about 40% coarse fragments; and 44-54" contains about 75% coarse fragments	N/A
HOLE #122			
A	0-5	black 10YR 2/1; very friable; loam	II
Bhs	5-32	dark reddish-brown 2.5YR 3/4; very friable; loam	II
Bt	32-36	dark reddish-brown 2.5YR 3/4; friable; clay loam	III
R	36	Hole terminated on rock; 0-2" contains about 75% coarse fragments; and 2-36" contains about 20% coarse fragments	N/A
HOLE #123			
A	0-4	black 10YR 2/1; very friable; loam	II
Bhs	4-22	dark reddish-brown 2.5YR 3/4; very friable; loam	II
Bt	22-40	dark reddish-brown 2.5YR 3/4; friable; clay loam	III
2Bt	40-60	dark red 2.5YR 3/6; friable; loam; 0-60" contains about 35% coarse fragments	II
HOLE #124			
A	0-4	black 10YR 2/1 very friable; loam	II
B	4-11	dusky red 10YR 3/3 very friable; loam	II
Bhs	11-35	dark red 10R 3/6 friable; loam	II
Bt1	35-50	dark red 10R 3/6; friable; clay loam	III
Bt2	50-72	dark red; heavy clay loam; 0-10" contains about 70% coarse fragments; and 10-72" contains about 35% coarse fragments	III
HOLE #125		(old HOLE #37)	
A	0-2	black 10YR 2/1; very friable; loam	II
Bhs	2-27	dark reddish-brown 2YR 3/4; very friable; loam	II
Bt1	27-44	dark reddish-brown 2.5YR 3/4; friable; light clay loam	III
Bt2	44-60	dark reddish-brown 2.5YR 3/4; friable; light clay loam 0-4" contains about 70% coarse fragments; and 4-60" contains about 15% coarse fragments	III
HOLE #126			

A	0-2	black 10YR 2/1; very friable; loam	II
B	2-11	dark reddish-brown 2.5YR 2.5/4; very friable; loam	II
Bhs	11-25	dark red 2.5YR 3/6; very friable; loam	II
R	25	Hole terminated on rock; 0-25" contains about 60% coarse fragments	N/A
HOLE #127		(old HOLE #36) See Hole #36 for description	
HOLE #128			
A	0-2	10YR 2/1 black; very friable; loam	II
Bhs	2-19	dark red 10R 3/6; very friable; loam	II
Bt1	19-33	dark red 10R 3/6; loam to light clay loam; friable	II/III
Bt2	33-60	dusky red 10R 3/4; light clay loam; friable	III
HOLE #129			
A	0-2	black 10YR 2/1; very friable; loam	II
Bhs	2-19	dark red 10R 3/6; very friable; loam	II
Bt1	19-33	dark red 10R 3/6; loam to light clay loam; friable	II/III
Bt2	33-60	dark reddish-brown 10R 3/4; light clay loam; 0-10" contains about 15% coarse fragments; and 10-60" contains about 35% coarse fragments	III
HOLE #130			
A	0-2	black 10YR 2/1; very friable; loam	II
Bhs	2-17	dark reddish-brown 10.5YR 3/4; friable; loam	II
Bt	17-45	dusky red 10R 3/4; friable; light clay loam	III
2Bb	45-50	dusky red; friable with white	IV
C	50+	white 7.5YR 8/0; clay; 0-21" contains about 20% coarse fragments; and 21-45" contains about 60% coarse fragments	IV
HOLE #131			
A	0-6	black 10YR 2/1; very friable; loam	II
Bhs	6-14	dark brown 7.5YR 4/4; very friable; loam	II
Bt	14-25	dark brown; friable; light clay loam	III
2Cb	25-30	light brown 7.5YR 6/4; friable; clay loam	III
Cr	30	pink 7.5YR 7/4; sandy clay loam; friable to firm; 0-7" contains about 10% coarse fragments; and 7-30" contains about 15% coarse fragments	II
HOLE #132			
A	0-2	black 10YR 2/1; very friable; loam	II
Bhs	2-13	dark reddish-brown 2.5YR 3/4; friable; laom	II
Bt	13-29	dark reddish-brown 2.5YR 3/4; light clay loam	III
B	29-52+	red 10R 5/3; friable; clay; 0-10" contains about 25% coarse fragments; and 10-52" contains about 60% coarse fragments	IV
HOLE #133			
A	0-4	black 10YR 2/1; very friable; loam	II
Bhs	4-15	dark reddish-brown; friable; loam	II
Bt2	15-31	dark reddish-brown 2.5YR 3/4; friable; loam	II
C/2Bt	31-41	color ranges from dark reddish-brown to dark red; pliable clay to silty clay loam	III/IV
2Bt	41-90	reddish-brown; friable; silty clay loam; 0-90" contains about 30% coarse fragments	IV
HOLE #134			
A	0-3	black 10YR 2/1; very friable; loam	II
Bhs	3-12	weak red 10R 4/4; very friable; loam	II

Bt	12-48	weak red 10R 4/4; light clay loam; friable; 0-12" contains about 25% coarse fragments; and 12-48" contains about 70% coarse fragments	III
HOLE #135			
	0-2	black 10YR 2/1; very friable; loam	II
Bhs	2-8	dark red 2.5YR 3/6; very friable; loam	II
Bt	8-23	dark red 2.5YR 3/6; friable; light clay loam; 0-15" contains about 35% coarse fragments; and 15-23" contains about 50% coarse fragments	III
HOLE #136			
A	0-6	10YR 2/1; very friable; loam	II
Bhs	6-14	yellowish-red 5YR 5/8; very friable; loam	II
Bt	14-38	yellowish-brown; friable; light clay loam	III
R	38	hole terminated because of rock; 0-18" contains about 15% coarse fragments; and 18-38" contains about 50% coarse fragments	N/A
HOLE #137			
A	0-3	black 10YR 2/1; very friable; loam	II
Bhs	3-15	dark reddish-brown 2.5YR 3/4; very friable; loam	II
Bt	15-24	dark reddish-brown 2.5YR 3/4; friable; light clay loam	III
R	24	hole terminated due to rock; 0-24" contains about 25% coarse fragments	N/A
HOLE #138			
A	0-2	black; very friable; loam	II
Bhs	2-12	red 2.5YR 4/6; very friable; loam	II
Bt	12-32	red 2YR 4/6; friable; heavy loam	II
R	32	hole terminated due to rock; 0-32" contains about 60% coarse fragments	N/A
HOLE #139			
A	0-3	black 10YR 2/1; very friable; loam	II
Bhs	3-21	yellowish-brown 5YR 4/6; very friable; loam	II
Bt	21-26	yellowish-brown 5YR 4/6; light clay loam; friable	III
	26	Hole terminated due to rock	
N/A			
HOLE #140			
A	0-3	black 10YR 2/1; very friable; loam	II
Bhs	3-10	dark reddish-brown 2YR 3/4; very friable; loam	II
BC	10-19	dark red 2YR 3/6; friable; loam	II
C	19-30	dark red 2YR 3/6; friable; loam	II
2Bt	30-50	red 2YR 4/8; friable; clay loam; 0-19" contains about 20% coarse fragments; 20-50" contains about 40% coarse fragments	III
HOLE #141			
A	0-4	black 10YR 2/1; very friable; loam	II
Bhs	4-12	dark reddish-brown 2YR 3/4; very friable; loam	II
Bt	12-33	dark red 2.5YR 3/6; friable; loam	III
2Bt	33-75	red 2.5YR 4/8; friable; clay loam	III
2Bt	75-90	red 2.5YR 4/8; friable; clay loam; 0-36" contains about 15% coarse fragments; and 36-90" contains about 10% coarse fragments	III
HOLE #142			
A	0-3	black; very friable; loam	II

Bhs	3-20	dark red 2.5YR 3/6; very friable; loam	II
BC	20-29	dark red to a 2.5YR 3/6; friable; loam	II
Cb	29-42	dusky red; friable; clay loam	III
C	42-50	dusky red; friable; clay loam; 0-25" contains about 25% coarse fragments; 25-42" contains about 60% coarse fragments; and 42-50" contains about 70% coarse fragments	III
HOLE #142A			
A	0-2	black 10YR 2/1; very friable; loam	II
E	2-4	dark reddish-brown 2.5YR 2.5/4; very friable; loam	II
Bhs	4-18	dark reddish-brown 2.5YR 3/4; friable; loam	II
BC	18-44	dark reddish-brown 2.5YR 3/4; heavy loam; friable; 0-13" contains about 40% coarse fragments; and 13-44" contains about 65% coarse fragments	II
HOLE #143 (OLD HOLE #46 No New Description)			
HOLE #144			
A	0-4	black 10YR 2/1; very friable; loam	II
Bhs	4-17	dusky red 10R 3/4; very friable; loam	II
Bt	17-31	dusky red 10R 3/4; friable; heavy loam	II
BC	31-60	dark red 2.5YR 3/6; friable; sandy loam; 0-60" contains about 85% coarse fragments	II
HOLE #145			
A	0-4	black 10YR 2/1; very friable; loam	II
Bhs	4-20	dusky red 10R 3/4; very friable; loam	II
Bt	20-28	dusky red 10R 3/4; friable; light clay loam	III
BC	28-35	red 2.5YR 4/6; friable; clay loam	III
R	35	Hole terminated due to rock; chroma 2 mottles start at 32" and increase in intensity with depth; 0-35" contains about 35% coarse fragments	N/A
HOLE #146			
A	0-2	black 10YR 2/1; very friable; loam	II
Bhs	2-17	dusky red; very friable; loam	II
Bt	17-24	dusky red 10R 3/4; friable; light clay loam	III
BC	24-40	dark reddish-brown; friable; clay loam	III
R	40	Hole terminated due to rock; 0-20" contains about 15% coarse fragments; and 20-40" contains about 35% coarse fragments	N/A

#147, 148, 149 - There are no soil observations for these numbers.

HOLE #150			
A	0-5	black 10 YR 2/1; very friable loam	II
Bhs	5-17	dark red 2.5 YR 3/6; light clay loam to loam very friable	II/III
2Bt1	17-26	dark red 10 R 3/6; friable; light clay loam	III
2Bt2	26-55	dark brown 7.5 YR 3/4; friable; clay loam	III
HOLE #151			
A	0-2	black 10 YR 2/1; very friable loam	II
Bhs	2-6	dusky red 10 R 3/3; very friable loam	II
2Bt1	6-22	dark red 2.5 YR 3/6; friable; light clay loam to clay	

		loam	III
HOLE #152			
A	0-7	black 10 YR 2/1; very friable loam	II
Bhs	7-17	dark reddish-brown 2.5 YR 3/4; very friable loam	II
2Bt	17-40	dark reddish-brown 2.5 YR 3/4; friable; light clay loam	III
HOLE #153			
A	0-2	black 10 YR 2/1; very friable loam	II
Bhs	2-13	dark red 2.5 YR 3/6; very friable loam	II
2Bt1	13-27	red 2.5 YR 4/6; friable; clay loam	III
2Bt2	27-42	red 2.5 YR 4/6; friable; clay loam	III
HOLE #154			
A	0-2	black 10 YR 2/1; very friable; loam	II
Bhs	2-14	dark red 2.5 YR 3/6; very friable; loam	II
2Bt1	14-33	dark red 10 R 3/6; friable; clay loam	III
2Bt2	33-48	dark red 10 R 3/6; friable; clay loam	III
HOLE #155			
A	0-2	black 10 YR 2/1; very friable loam	II
Bhs	2-16	dark red 2.5 YR 3/6; very friable loam	II
2Bt1	16-46	dark red 2.5 YR 3/6; friable; light clay loam	III
2Bt2	46-70	dark red 10 R 3/6; friable; clay loam	III
HOLE #156			
A	0-2	black 10 YR 2/1; very friable loam	II
Bhs	2-18	dusky red 10 R 3/4; very friable loam	II
2Bt1	18-43	dark red 10 R 3/6; friable; light clay loam	II
2Bt2	43-70	dark red 10 R 3/6; friable; clay loam	III
HOLE #157			
A	0-2	black 10 YR 2/1; very friable loam	II
Bhs	2-12	dark red 10 R 3/6; very friable loam	II
Bt1	12-44	dark red 10 R 3/6; loam to a light clay loam; friable	II/III
Bt2	44-60	weak red 10 R 4/3; loam to light clay loam; friable	II/III
HOLE #158			
A	0-3	black 10 YR 2/1; very friable loam	II
Bhs	3-20	dark red 2.5 YR 3/6; very friable loam	II
2Bt1	20-45	dark reddish-brown 2.5 YR 3/4; friable; clay loam	III
2Bt2	45-60	red 2.5 YR 4/6; friable; light clay loam	II
HOLE #159			
A	0-2	black 10 YR 2/1; very friable loam	II
Bhs	2-12	dark red 2.5 YR 3/6; very friable loam	II
2Bt1	12-35	dark reddish-brown 2.5 YR 3/4; friable loam	II
2Bt2	35-55	dusky red 10 R 3/3; friable; heavy loam	II
C	55-60+	white 7.5 YR 7/0; friable clay	II
HOLE #160			
A	0-2	black 10 YR 2/1; very friable loam	II
Bhs	2-12	dark red 2.5 YR 3/6; very ~~friable; loam~~	II
Bt	12-33	dusky red 10 R 3/4; friable; light clay loam	III

C	33-46	yellowish-red 5 YR 5/8; friable; sandy clay loam	II
R	46		
HOLE #161			
A	0-2	black 10 YR 2/1; very friable; loam	II
Bhs	2-6	strong brown 7.5 YR 5/8; very friable loam	II
Bt1	6-22	strong brown 7.5 YR 5/8; friable; light clay loam	
		pinkish-gray to strong brown; friable to firm clay loam	III
		this hole was mottled with chroma 2 starting at 18"	
HOLE #163			
A	0-4	black 10 YR 2/1; very friable loam	II
Bhs	4-6	yellowish-red 5 YR 5/6; very friable loam	II
Bt1	6-14	yellowish-red 5 YR 5/6; friable; light clay loam	III
Bt2/C	14-28	strong brown 7.5 YR 5/8; firm; clay	IV
C	28-30	pinkish-gray 7.5 YR 7/2; firm; clay	IV
HOLE #162			
A	0-3	black 10 YR 2/1; very friable; loam	II
Bhs	3-12	dark red 2.5 YR 3/6; very friable; loam	II
Bt1	12-25	dark red 2.5 YR 3/6; friable; loam	II
2Bt2	25-45	dusky red 10 R 3/4; friable; loam to light clay loam	II/III
HOLE #164			
A	0-7	black 10 YR 2/1; very friable loam	II
Bhs	7-18	yellowish-red 5 YR 4/6; very friable loam	II
2Bt1	18-33	yellowish-red 5 YR 4/6; friable; light clay loam	III
2Bt2	33-53	reddish-yellow 7.5 YR 6/6; friable; clay loam to clay mottled with chroma 2 mottles starting at 40"	III/IV
HOLE #165			
	0-2	black 10 YR 2/1; very friable loam	II
Bhs	2-10	dark reddish-brown 5 YR 3/4; very friable loam	II
2Bt1	10-18	reddish-brown 5 YR 4/4; friable; light clay loam	III
C	18-40	brown 7.5 YR 5/4; firm clay to clay loam mottled starting at 40" with gray mottles which increase in intensity with depth	III/IV
HOLE #166			
A	0-6	black 10 YR 2/1; very friable loam	II
Bhs	6-12	reddish-brown 5 YR 4/4; very friable loam	II
2Bt	12-23	strong brown 7.5 YR 5/6; friable loam	II
2Bt/C1	23-41	strong brown 7.5 YR 5/8; friable to firm; clay loam to clay mottled with gray; gray mottles start at 34"	III/IV
C2	41-45	white 7.5 YR 8/0; firm clay	IV
HOLE #167			
A	0-8	black 10 YR 2/1; very friable loam	II
Bhs	8-16	yellowish-red 5 YR 4/6; very friable loam	II
Bt1	16-30	strong brown 7.5 YR 5/6; friable loam to sandy loam	II
Bt2	30-52	strong brown 7.5 YR 5/6; friable; heavy clay loam	II
HOLE #168			
A	0-2	black 10 YR 2/1; very friable loam	II
Bhs	2-10	reddish-brown 5 YR 4/4; very friable loam	II
2Bt1	10-25	strong brown 7.5 YR 5/6; friable; loam to sandy loam	II
Bt2	25-40	strong brown 7.5 YR 5/6; friable loam to sandy loam	II

HOLE #170			
A	0-2	black 10 YR 2/1; very friable loam	II
Bhs	2-12	dark reddish-brown 2.5 YR 3/4; very friable loam	II
Bt	12-30	dark red 2.5 YR 3/6; friable loam	II
HOLE #171			
A	0-2	black 10 YR 2/1; very friable loam	II
Bhs	2-14	dark reddish-brown 2.5 YR 3/4; very friable loam	II
Bt1	14-28	dark red 2.5 YR 3/6; friable loam	II
Bt2	28-43	dark red; friable; 2.5 YR 3/6 loam	II
C	43+	white 7.5 YR 8/0; friable clay	IV
HOLE #172			
A	0-3	black 10 YR 2/1; very friable loam	II
Bhs	3-10	dark red 2.5 YR 3/6; very friable loam	II
Bt1	10-23	dark reddish-brown 2.5 YR 3/4; friable loam	II
HOLE #173			
A	0-6	black 10 YR 2/1; very friable loam	II
Bhs	6-20	strong brown 7.5 YR 5/6; very friable loam	II
2Bt1	20-29	strong brown 7.5 YR 5/6; friable light clay loam	III
2Bt3	29-43	dark red 2.5 YR 3/6; firm clay loam	III
C	43-53	pinkish-white 5 YR 8/2; firm clay	IV
HOLE #174			
A	0-7	black 10 YR 2/1; very friable loam	II
Bhs	7-10	yellowish-red 5 YR 4/6; very friable loam	II
2Bt	10-22	strong brown 7.5 YR 5/6; friable clay loam	III
C	22-50	pink 7.5 YR 7/4; firm clay	IV
HOLE #175			
A	0-10	black 10 YR 2/1; very friable loam	II
Bhs	10-17	strong brown 7.5 YR 4/6; very friable loam	II
[illegible]	17-23	strong brown 7.5 YR 5/8; friable light clay loam	III
HOLE #176			
A	0-2	black 10 YR 2/1; very friable loam	II
Bhs	2-9	dark reddish-brown 5 YR 3/3; very friable loam	II
2Bt	9-26	dark reddish-brown 5 YR 3/3; friable; heavy loam	II
2Bt2/C	26-55	dark red 2.5 YR 3/6; friable clay loam	III
HOLE #177			
A	0-2	black 10 YR 2/1; very friable loam	II
Bhs	2-12	dark brown 7.5 YR 3/4; very friable loam	II
Bt1	12-33	strong brown 7.5 YR 5/6; friable; clay loam	III
Bt2	33-56	yellowish-red 5 YR 5/6; clay loam to clay; friable mottled starting at 40" with gray and weak red	III/IV
HOLE #178			
A	0-1	black 10 YR 2/1; very friable loam	II
Bhs	1-3	yellowish-red 7.5 YR 4/6; very friable loam	II
Bt1	3-22	strong brown 7.5 YR 4/6; friable; light clay loam	III
C1	22-63	reddish-brown to a light reddish-brown 7.5 YR 5/4 and 5 YR 5/6; friable; clay to clay loam mottled with gray and weak red	III/IV
C2	63-70	light gray 7.5 YR 7/0; friable clay mottled with dusky red and gray; gray mottling starts at 24" and increases in intensity with depth	IV
HOLE #179			
A	0-5	black 10YR 2/1; very friable; loam	II
Bhs	5-9	dark brown; 7.5 YR 3/2; very friable; loam	II

Bt	9-25	strong brown; 7.5 YR 4/6; friable; loam	II
C	25-63	strong brown 7.5 YR 5/8; friable; clay loam mottled with weak red, dusky red, and gray; chroma 2 colors start at 38"	III
HOLE #180			
A	0-1	black 10 YR 2/1; very friable; loam	II
Bhs	1-9	reddish-brown 7.5 YR 4/4; very friable; loam	II
Bt1	9-36	dark reddish-brown 5YR 3/5; friable; clay loam	III
Bt2	36-52	dark reddish-brown 2.5 YR 3/4; friable; clay loam	III
C	52-59	light gray 7.5 YR 7/0; friable; clay	IV
HOLE #181			
A	0-2	black 10YR 2/1; very friable; loam	II
Bhs	2-9	dark reddish-brown 5 YR 3/3; very friable; loam	II
Bt1	9-23	reddish-brown 5 YR 4/4; friable; loam	II
Bt2	23-38	weak red 10 R 4/4; friable; light clay loam	III
Bt3/C	38-60	strong brown to light gray 7.5 YR 7/0; 7.5 YR 5/6 friable; clay mottled with dusky red and gray; chroma 2 colors start at 38" and increase in intensity with depth	IV
HOLE #182			
A	0-4	black 10 YR 2/1; very friable; loam	II
Bhs	4-9	dark brown 7.5 YR 3/2; very friable; loam	II
Bt1	9-23	reddish-brown 5 YR 4/4; friable loam	II
Bt2	23-38	reddish-brown 5 YR 4/4; friable; loam	II
C	38-70	strong brown to light gray 7.5 YR 5/6; 7.5 YR 7/0; friable; clay loam mottled with weak red, yellowish-red, dusky red and gray; gray mottles start at 38"	III
HOLE #183			
A	0-2	black 10 YR 2/1; very friable; loam	II
Bhs	2-12	yellowish-red 5 YR 5/6; very friable; loam	II
Bt1	12-16	yellowish-red 5 YR 5/6; friable; light clay loam	III
Bt2	16-26	yellowish-red 5 YR 5/8 to a light gray 7.5 YR 7/0 friable; clay loam	
C	26-70	yellowish-red 5 YR 5/8; friable; clay loam mottled with yellowish-red, weak red dusky red, and gray; chroma 2 colors start at 26" and increase in intensity with depth	II
HOLE #184			
A	0-3	black 10 YR 2/1; very friable loam	II
Bhs	3-13	dark brown 7.5 YR 3/4; very friable loam	II
Bt	13-36	yellowish-red 5 YR 4/6; friable; light clay loam	III
C	36-48	light gray 7.5 YR 7/0; friable; clay mottled with strong brown, weak red, and dusky red; chroma 2 colors start at 36"	IV
HOLE #185			
A	0-3	black 10 YR 2/1; very friable loam	II
Bhs	3-12	dark red 2.5 YR 3/6; very friable loam	II
Bt1	12-20	dark red 2.5 YR 3/6; friable loam	II
Bt2	20-45	dark red 2.5 YR 3/6; friable; light clay loam	III
HOLE #186			
A	0-8	black 10 YR 2/1; very friable loam	II
Bhs	8-19	dark reddish-brown 2.5 YR 3/4; very friable loam	II

2Bt	19-32	strong brown 7.5 YR 5/6; friable loam	II
HOLE #187			
A	0-2	black 10 YR 2/1; very friable loam	II
Bhs	2-12	dark red 2.5 YR 3/6; very friable loam	II
Bt	12-26	dark red 2.5 YR 3/6; friable loam	II
HOLE #188			
A	0-2	black 10 YR 2/1; very friable loam	II
Bhs	2-11	dark reddish-brown 2.5 YR 3/4; very friable loam	II
2Bt	11-48	dark reddish-brown 2.5 YR 3/4; friable loam	II
2C	48-60	dark red to light gray 2.5 YR 3/6 to 7.5 YR 7/8; friable clay; also mottled with a weak red and dusky red; chroma 2 colors start at 48"	IV

HOLE #L1		This pit is dug to a depth of 11+ feet.
	0'-1.0'	black; friable; loam
	1.0'-3.0'	dark brown to yellowish-red; friable; heavy loam; 20% coarse fragments which range in the long dimension to a width of about three feet and some of them are as much as six inches in thickness
	3.0'-11.0'+	dark reddish-brown to weak red; clay loam to sandy clay loam containing about the same coarse fragment content; seepage water is entering the hole at about 4' and at the bottom of the pit

HOLE #L2		
A	0'-1.0'	black; friable; loam
B2	1.0'-4.0'	yellowish-brown to gray; heavy sandy clay loam with streaks of sandy clay
C	4.0'-12.0'	yellowish-brown; sandy loam to sandy clay loam NOTE: Fragment content is about 15% throughout the profile with a concentration of large flat stones near the surface and a few scattered throughout. At the surface the stones are as much as 6 to 7 feet in the long dimension Those encountered deeper in the hole are less than 3 feet. seepage water starts in the hole at about 5 feet below the surface; soil color indications are that this water will come into the hole near the surface during the wet season of the year

HOLE #L3		
	0'-1.0'	black; very friable; sandy loam to loam
B2	1.0'-3.5'	gray; friable; sandy loam to sandy clay
C	3.5-11.0'+	yellowish-brown mottled with strong brown and gray; friable; sand to sandy loam; coarse fragment content in the upper 4 feet is 40 to 50% and fragments range from a few inches to 3 feet; some of the fragments near the soil surface are 6 feet in long dimension and 6 inches thick; from 4 to 12 feet, the fragment content reduces to about 10% and consist of smaller fragments. Seepage water is entering the hole at about two feet below the surface

HOLE #L4		
A	0'-1.0'	black; very friable; gravelly loam; contains stone fragments one foot in thickness by six feet in length; these large fragments tend to be concentrated in the upper foot or so of the profile
B	1.0'-5.5'	reddish-brown to weak red; friable; loam to light clay loam; contains about 30% coarse fragments ranging from a few inches to 2 feet in the long dimension
IIB	5.5'-10.5'+	weak red to olive brown; clay containing 10% fragments most fragments range from one or two inches to five or six inches; seepage is starting in the hole at about

three below the surface; there is a concentration of mangenese concretions at about 5.5 feet at one end of the pit

HOLE #L5

A	0'-0.5'	black; very friable; loam
B2	0.5'-3.5'	reddish-brown which quickly grades to weak red mottled with gray; friable; light clay loam
C1	3.5'-8.5'	weak red mottled with gray; friable; clay loam
C2	8.5'-11.5'	weak red; friable; gravelly sandy loam to sandy clay loam; this horizon is water bearing and has seepage water starting at about seven or eight feet and flowing into the pit

NOTE: Fragment content for this hole is not as much as the earlier holes; fragments range from a few inches to 1.5' in long dimension and represent 10-15% of the profile

HOLE #L6

A	0'-0.5'	black; very friable; loam
C1	0.5'-6.0'	dark reddish-brown; very friable to friable; loam; containing about 25% sandstone fragments ranging from less than one inch to 1½ feet and in long dimension
C2	6.0'-11.5'	weak red; friable; sandy clay loam to clay loam containing about 25% fragments; this horizon is water-bearing, and is saturated throughout and has seepage water starting in the hole at about six feet

HOLE #L7

A	0'-5.0'	dark reddish-brown; very friable; loam
B21	5.0'-2.5'	reddish-brown; friable; loam grading to clay loam mottled in the lower part with yellowish-brown, pale yellow and gray
B22	2.5'-9.0'	mottled and streaked gray, yellowish-brown, pale yellow, and reddish-brown; firm; plastic; clay to heavy clay loam; contains lenses of highly weathered sand stone; this material has developed from an inter-bedded sandstone and shale; it is still easily dug with a backhoe at nine feet

HOLE #L8

A	0'-0.5'	black to dark reddish-brown; very friable; loam
B21	0.5'-2.0'	dark reddish-brown mottled in the lower part with weak red; friable; loam
B22	2.0'-6.0'	mottled gray, weak red, reddish-brown, and yellowish-brown; massive which breaks to coarse angular blocky; clay to silty clay
B3	5.0'-9.5'	gray mottled with weak red and yellowish-brown; friable; massive silty clay

NOTE: Reddish-brown material goes to about four feet on one end of the pit and 1½ feet on the other.
There is a concentration of colluvial fragments in the upper profile which extends to a depth of 3½ to 4 feet; below that point the soil profile is reasonably free of

fragments and appears to have weathered from an inter bedded shale and sandstone; the sandstone portion appears to be thinly bedded silty sand stone

HOLE #L9

	0'-1.0'	dark brown to dark reddish-brown; very friable; loam with a few fragments
B	1.0'-9.5'	dark reddish-brown mottled and streaked with strong brown, yellowish-brown, and weak red; friable; heavy clay loam to light clay; contains about 10% fragments in the upper four feet and 1-3% fragments below there; there is no distinct evidence of a water table in this hole

HOLE #L10

A	0'-0.5'	dark brown to dark reddish-brown; very friable; loam;
E	0.5'-2.5'	brown to strong brown; friable; loam containing 5-10% hematite sandstone fragments; one end of the pit has clay loam to clay soils with gray colors
R	2.5'	bedrock

HOLE #L11

A/E	0'-1.5'	dark reddish-brown which grades to weak red; friable; loam to light clay loam
B2	1.5'-3.5'	gray mottled with weak red; massive clay to silty clay
C1	3.5'-4.5'	ocre; loam; weathered hematite sandstone which is difficult to dig with the backhoe
R	4.5+'	bedrock

HOLE #L12

A	0'-1.5'	dark reddish-brown; very friable; loam
/B	1.5'-2.5'	dark reddish-brown which quickly grades to weak red; friable; loam to silty clay loam
B2	2.5'-6.0'	gray mottled with weak red, reddish-brown, and yellowish-brown; friable; silt loam to silty clay loam
2C	6.0'-9.0'+	mottled yellowish-brown and gray; silt loam from bedded shale and sandstone

HOLE #L13

A/E	0'-1.5'	dark reddish-brown; very friable; loam containing 10 to 12% fragments
B2	1.5'-3.5'	gray mottled and streaked with weak red and reddish-brown; friable; silty clay to clay; containing numerous sandstone fragments
R	3.5'	weathered sandstone rock containing clay seams which is difficult to dig with a hoe

REMARKS: Sandstone fragments associated with dark reddish-brown, red and dusky red soil colors are usually derived from hematite rich sandstones.

Horizons designated R do not necessarily reflect bedrock conditions. A significant number of cases exist where the rock appeared to be transported material which was too large for the small backhoe to move without difficulty

NOTES: Holes #31 through #47 were described by visual inspection without the aid of a colorbook. There are no soil observations for numbers, 48 through 99, and 147, 148, & 149.

Profile descriptions 1 - 47 and L1 - L13 by H. Mathews; 100-146 by A. Siebel, T. Simpson and H. Mathews; 150-188 by A. Siebel.

Most holes (backhoe pits) were excavated with a case model 580D rubber-tired backhoe

SITE EVALUATED: Holes 1-30, November 23-25, 1984; Reconnaissance survey of property: Holes 31-47, March 20, 1985; Grid "best" site to evaluate soil depth and potential use: Holes 100-146, October 17-23, 1985; Evaluate alternate sites: Holes 150-188, October 23-24, 1985; Evaluate alternate site: Holes L1-L13, October 16, 1985; Evaluate Lagoon sites.

SOIL TEST ANALYSIS

Sample No.: PIT #14
Map Unit No.: 1
Soil Type: MT. COLLUVIUM
Date of Sampling: ____

Sheet 1 of ____
Sampled by: DR. T. W. SIMPSON
Analyzed by: A & L LABS
Date of Analysis: 3/5/86

PARAMETER	Results of Analysis*	
	A	2B
Sample Depth (horizon limits) cm	5-23	74-69
Soil Organic Matter, %	3.0	0.7
Soil pH, (Std Units)	4.8	4.6
Cation Exchange Capacity, me/100g	8.6	7.5
Total Nitrogen, ppm	1400	400
Organic Nitrogen, ppm	1350	400
Ammonia Nitrogen, ppm	40	<10
Total Phosphorus, ppm	1160	870
Available Phosphorus, ppm	57	11
Exchangeable Sodium, me/100g	62	40
Exchangeable Calcium, me/100g	60	30
Exchangeable Magnesium, me/100g	9	5
Exchangeable Acidity, me/100g	7.8	7.0
Copper, ppm	23	22
Nickel, ppm	10	5
Zinc, ppm	48	26
Cadmium, ppm	<0.5	<0.5
Lead, ppm	10	10
Chromium, ppm	35	35
Manganese, ppm	229	66
Other Parameters (list):		

*Reported on a dry weight basis.

SOIL TEST ANALYSIS

Sample No.: PIT #15	Sheet 1 of 1
Map Unit No.: 1	Sampled by: DR. T. W. SIMPSON
Soil Type: MT. COLLUVIUM	Analyzed by: A & L LABS
Date of Sampling:	Date of Analysis: 3/5/86

PARAMETER	Results of Analysis* Sample Depth: cm		
	A	2B21	2B22
Sample Depth (horizon limits) cm	5-20	39-62	62-100
Soil Organic Matter, %	3.7	0.9	0.8
Soil pH, (Std Units)	4.7	4.6	4.8
Cation Exchange Capacity, me/100g	8.5	9.0	9.3
Total Nitrogen, ppm	2100	400	70
Organic Nitrogen, ppm	2070	40	70
Ammonia Nitrogen, ppm	20	<10	<10
Total Phosphorus, ppm	860	650	800
Available Phosphorus, ppm	15	6	3
Exchangeable Sodium, me/100g	43	44	44
Exchangeable Calcium, me/100g	10	20	70
Exchangeable Magnesium, me/100g	8	4	35
Exchangeable Acidity, me/100g	8.1	8.6	8.4
Copper, ppm	23	18	26
Nickel, ppm	5	5	15
Zinc, ppm	65	43	64
Cadmium, ppm	<0.5	<0.5	<0.5
Lead, ppm	10	10	15
Chromium, ppm	25	40	45
Manganese, ppm	625	209	207
Other Parameters (list):			

*Reported on a dry weight basis.

SOIL TEST ANALYSIS

Sample No.: PIT #34
Map Unit No.: 1
Soil Type: MT. COLLUVIUM
Date of Sampling: ____________

Sheet 1 of 1
Sampled by: DR. T. W. SIMPSON
Analyzed by: A & L LABS
Date of Analysis: 3/5/86

PARAMETER	Results of Analysis* Sample Depth: cm		
	A	2B21	2B22
Sample Depth (horizon limits) cm	3-20	43-108	108-150
Soil Organic Matter, %	4.1	0.4	0.7
Soil pH, (Std Units)	4.7	4.8	5.0
Cation Exchange Capacity, me/100g	3.2	3.7	9.2
Total Nitrogen, ppm	1100	200	400
Organic Nitrogen, ppm	1070	190	390
Ammonia Nitrogen, ppm	11	10	7
Total Phosphorus, ppm	1570	700	1220
Available Phosphorus, ppm	73	13	7
Exchangeable Sodium, me/100g	68	69	62
Exchangeable Calcium, me/100g	30	40	50
Exchangeable Magnesium, me/100g	11	5	26
Exchangeable Acidity, me/100g	2.5	3.1	8.3
Copper, ppm	19	14	37
Nickel, ppm	5	10	25
Zinc, ppm	56	24	56
Cadmium, ppm	<0.5	<0.5	56
Lead, ppm	10	100	20
Chromium, ppm	25	20	60
Manganese, ppm	219	86	117
Other Parameters (list):			

*Reported on a dry weight basis.

ATTACHMENT G

Groundwater Monitoring Plan

GROUNDWATER MONITORING PLAN SUMMARY
Mountain Lake Spray Irrigation System

BACKGROUND CONDITIONS

Geology

The area around Mountain Lake is a breached inlier, that is older rocks surrounded by younger rocks in normal stratigraphic sequence. The youngest rocks exposed in the proposed area are sandstones of Silurian Age (Tonoloway and Keefer Fm.) underlain by the Rose Hill Fm, (Srh); the Tuscarora Fm. (St); the Juniata Fm (Oj) and the Martinsburg and Reedsville (Fms) of Ordovician Age.

The south end of the lake is underlain by the Martinsburg and Juniata Fms. while the north end is underlain by the Tuscarora and Rose Hill Fms. The south end has been breached by erosion of Doe creek during a past geologic east at about 14 degrees. There are no known faults in the general area. Hemlock Branch appears to be a minor shear or fracture filled with colluvium (mainly Rose Hill sandstone).

Weathering is deep as the sandstones have been leached of a great deal of their cementing material. From the appearance of many of the test pits, the soil is quite sandy and mixed with organic material. Bedrock is exposed at the surface especially on the ridge line along the road to the golf course. Some outcrops can be seen around the hotel. The structure at Mountain Lake is synclinal.

Hydrogeolgy

Seasonal water table does not appear to exist in the shallow soil profiles (three to seven feet below the soil surface) of the site. Depth to the water table at the application site is in the order of 30 to 40 feet below the soil surface and appears to be locally controlled by topographic and geologic features. The direction of groundwater flow is thought to correspond to topographic relief. Water movement is in the direction of surface topography. Measurement of groundwater elevations during routine monitoring appears to confirm this assumption. The gradient appears to be dipping to the north at slope of about 10 percent. The average surface slope in this area is about 13 percent. No groundwater dye test or pumping analysis have been conducted. A groundwater mounding analysis was performed by Dr. Daniel Fritton of the Pennsylvania State University, prior to design and was included in the Preliminary Engineering Report previously reviewed by the VWCB.

MONITORING

Sites

Groundwater is presently being monitored at four sites:

Site 1: Depth: 100 feet Upgradient monitoring well south of spray field.
State Plane Coordinates: N 380424.71, E 1404766.10
Top of Casing Elevation: 4171.02 feet
Groundwater Elevation (June 1991): 4139 feet
Sampled by permanently set bladder pump
Formerly designated U-1

Site 2: Upgradient spring southeast of spray field.
State Plane Coordinates: N 380300, E 1405861
Elevation at sample point: 4062 +/- feet
Groundwater Elevation (June 1991): 4062 feet
Sampled by direct collection
Formerly designated U-2

Site 3: Downgradient spring north of spray field
State Plane Coordinates: N 382616, E 1405121
Elevation at sample point: 3936 +/- feet
Groundwater Elevation (June 1991): 3936 +/- feet
Sampled by direct collection
Formerly designated D-1

Site 4: Downgradient monitoring well northwest of spray field.
Depth: 7 feet
State Plane Coordinates: N 382809, E 1439775 (approx.)
Top of Casing Elevation: 3869 +/- feet
Groundwater Elevation (June 1991): 3863 feet
Sampled by bailer
Formerly designated D-2

Surface water is presently being monitored at one site:

Site 7: Pond Drain, below spray field in the vicinity of the Mountain Lake property line.

Periodic sampling has been conducted at other sites both prior to and since the spray irrigation system began operation. Most of this sampling and analysis was conducted by the Departments of Biology and Forestry at Virginia Tech. This sampling included the following sites:

Site 5: Treated effluent from the sample tap at the irrigation pump station.

Site 6: Pond Drain at the discharge of Mountain Lake near the Lake House.

Site 8: Tributary to Pond Drain located at an H-flume installed approximately 300 feet downstream of Site 3.

Parameters

Groundwater is sampled quarterly at Sites 1, 2, 3, and 4 by Mountain Lake personnel. Samples are analyzed by a commercial laboratory (presently Olver, Inc. of Blacksburg). The following parameters are analyzed and reported on the monthly No-Discharge Certificate Monitoring Report:

Groundwater Elevation
pH
Ammonia (as N)
Nitrates (as N)
Chemical Oxygen Demand
Total Coliform
Chlorides
Specific Conductance

Surface water is sampled twice per year, typically spring and fall at Site 7 by Mountain Lake personnel. Samples are analyzed by a commercial laboratory for the following parameters

pH
Ammonia (as N)
Nitrates (as N)
Chlorides

Mountain Lake Wastewater System
VPA Application
Recent Groundwater Monitoring Results

Site	Quarter/Year	Static Water Level	Chlorides	Conductivity	Nitrate Nitrogen	pH
Site #1	Upgradient Monitoring Well					
3rd	2010	85.19	N/D	306	N/D	5.09
4th						
1st	2011	84.75	<QL	27.6	<QL	6.02
2nd	2011	84.88	<QL	305	<QL	5.51
3rd	2011	85.5	<QL	307	<QL	5.44
Site #2	Upgradient Monitoring Spring					
3rd	2010	N/A	N/D	26	N/D	5.28
4th	2010	N/A	0.43	15.28	0.04	6.99
1st	2011	N/A	<QL	21.1	<QL	7.02
2nd	2011	N/A	<QL	15.28	<QL	6.25
3rd	2011	N/A	N/A	N/A	N/A	N/A
Site #3	Downgradient Monitoring Spring					
3rd	2010	N/A	2.19	26.2	N/D	5.69
4th	2010	N/A	1.44	24.3	0.56	6.56
1st	2011	N/A	1.06	20.9	0.6	6.85
2nd	2011	N/A	5.23	54.5	2.04	6.11
3rd	2011	N/A	10.2	97	3.9	6.02
Site #4	Downgradient Monitoring Well					
3rd	2010	10.47	N/D	10.56	N/D	5.21
4th	2010	5.6	0.52	9.03	0.09	5.11
1st	2011	3.7	<QL	7.56	0.1	5.17
2nd	2011	5.56	<QL	7.78	0.11	5.03
3rd	2011	10.93	N/A	8.92	N/A	5.12

ATTACHMENT H

Pertinent Calculations

DESIGN VALUES

FOREST SPRAY IRRIGATION SYSTEM - HYDRAULIC STORAGE DESIGN
Mountain Lake Wastewater Project J.N. 4837

VARIABLES:

Qd	Average Daily Design Flow (gpd)	
Qm	Monthly Accumulated Wastewater (gal)	
Ld	Design Wastewater Loading (in/acre month)	
Lm	Design Wastewater Volume Applied (gal/month)	
Pr	Precipitation (in/month)	
ET	Evapotransporation (in/month)	
Sm	Change in Stored Wastewater Volume (gal/month)	
Sb	Stored Wastewater Balance (gal)	
A	Active Application Area (acres).............	12.0

CALCULATIONS:

Ld is derived from WASTEWATER LOADING RATE DESIGN

Sm = Qm - Lm + ((Pr - ET) * 27200)

Month	Qd gpd	Qm gal/mo	Ld in/mo	Lm gal/mo	Pr in/mo	ET in/mo	Sm gal	Sb gal
JAN	21400	663400	0.0	0			663400	663400
FEB	21400	599200	0.0	0			599200	1262600
MAR	16400	508400	2.3	750720			-242320	1020280
APR	18500	555000	2.5	816000			-261000	759280
MAY	19500	604500	3.2	1044480			-439980	319300
JUN	25500	765000	3.7	1207680			-442680	0
JUL	31500	976500	4.0	1305600			-329100	0
AUG	31500	976500	3.7	1207680			-231180	0
SEP	23500	705000	3.2	1044480			-339480	0
OCT	26700	827700	2.3	750720			76980	76980
NOV	20600	618000	1.8	587520			30480	107460
DEC	26700	827700	0.0	0			827700	935160
ANNUAL	23600	8626900	26.7	8714880	0	0	-87980	
JAN	21400	663400	0.0	0			663400	1598560
FEB	21400	599200	0.0	0			599200	2197760
MAR	16400	508400	2.3	750720			-242320	1955440
APR	18500	555000	2.5	816000			-261000	1694440
MAY	19500	604500	3.2	1044480			-439980	1254460
JUN	25500	765000	3.7	1207680			-442680	811780
JUL	31500	976500	4.0	1305600			-329100	482680
AUG	31500	976500	3.7	1207680			-231180	251500
SEP	23500	705000	3.2	1044480			-339480	0
OCT	26700	827700	2.3	750720			76980	76980
NOV	20600	618000	1.8	587520			30480	107460
DEC	26700	827700	0.0	0			827700	935160
ANNUAL	23600	8626900	26.7	8714880	0	0	-87980	

DESIGN VALUES

FOREST SPRAY IRRIGATION SYSTEM - WASTEWATER LOADING RATE DESIGN
Mountain Lake Wastewater Project J.N.4837

VARIABLES:

Pr	Precipitation Percolating into Soil (in/month)	
r	Runoff Fraction of Precipitation................	0.0
ET	Evapotranspiration (in/month)	
Pm	Measured Percolation Rate (min/in)..............	45.0
Pw	Design Percolation Rate (in/day)	1.3
Lh	Hydraulic based Loading Rate (in/month)	
U	Nitrogen Uptake Rate (lb/acre year).............	50.0
Ln	Nitrogen based Loading Rate (in/month)	
Cp	Limiting Percolate Nitrogen Conc. (mg/l)........	5.0
Cn	Applied Wastewater Nitrogen Conc. (mg/l)........	21.0
f	Fraction of Applied Nitrogen Removed by Denitrification and Volitilization.........	0.2
Ld	Design Wastewater Loading (in/month)	

CALCULATIONS: (EPA 625/1-81-013 Land Treatment of Mun. Wastewater)

Pw is based on 4% of measured permiability (Pm)

$$Lh = ET - Pr + Pw$$

$$Ln = \frac{(Cp)\ (Pr - ET) + (U)\ (10)}{(1 - f)\ (Cn) - Cp}$$

U monthly values are distributed in same proportion as ET

Month	Pr in/mo	ET in/mo	Net ET in/mo	Pw in/mo	Lh in/mo	U lb/acmo	Ln in/mo	Ld in/mo
JAN	4.1	-0.3	-4.4	0.0	0.0	-0.7	1.4	0.0
FEB	4.2	-0.1	-4.3	0.0	0.0	-0.3	1.6	0.0
MAR	5.2	0.5	-4.6	15.4	10.7	1.4	2.3	2.3
APR	4.3	1.6	-2.8	30.7	28.0	4.2	2.5	2.5
MAY	5.0	2.4	-2.7	39.7	37.0	6.4	3.2	3.2
JUN	5.4	3.1	-2.4	38.4	36.0	8.2	3.7	3.7
JUL	5.8	3.4	-2.4	39.7	37.3	9.1	4.0	4.0
AUG	5.0	3.3	-1.8	39.7	37.9	8.8	3.7	3.7
SEP	4.6	2.7	-2.0	38.4	36.5	7.1	3.2	3.2
OCT	3.6	1.7	-1.9	32.0	30.1	4.6	2.3	2.3
NOV	3.6	0.7	-2.9	16.6	13.7	1.8	1.8	1.8
DEC	4.3	-0.2	-4.5	0.0	0.0	-0.5	1.6	0.0
ANNUAL	55.1	18.7	-36.4	290.6	267.3	50.0	31.3	26.8

If the average daily flow is.................... 0.0236 M.G.D.
the required application area is: 11.9 acres
and the resulting TOTAL NITROGEN loading is: 127.2 lb/ac yr

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JOB MOUNTAIN LAKE WW 79501.2

SHEET NO. ______ OF ______

CALCULATED BY QSC DATE 12/17/91

CHECKED BY ______ DATE ______

SCALE ______

CHLORINE CONTACT TIME:

CONTACT TIME IS PROVIDED WITHIN THE FORCE MAIN WHICH WILL PROVIDE A TRUE PLUG FLOW SITUATION.

TOTAL FORCE MAIN LENGTH = 3594'

FORCE MAIN DIAMETER = 6"

FORCE MAIN VOLUME $= \frac{\pi(.5)^2}{4}(3594)(7.48\ gal/ft^3) = 5278\ gal.$

DETENTION TIME @ AVG DESIGN FLOW = 35,000 gpd (24.3 gpm)

$$T_{AVG} = \frac{5278}{24.3} = 217\ min$$

DETENTION TIME @ PUMPING RATE = 130 gpm

$$T_{MIN} = \frac{5278}{130} = 41\ min > 30\ min\ reqd \therefore OK$$

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JOB MOUNTAIN LAKE W.W. JN 4031
SHEET NO ______ OF ______
CALCULATED BY QSC DATE 12/06/85
~~CHECKED BY~~ REVISED TO INCREASE FLOWRATES QSC DATE 1/22/86
SCALE ______

SPRAY IRRIGATION SYSTEM

PLANT CAPACITY : 35,000 gpd
ANTICIPATED ANNUAL AVG. FLOW (STARTUP) : 14,000 gpd
" " " " (ULTIMATE) : 23,600 gpd

LIQUID LOADING:

USE A MAXIMUM LOADING RATE OF 30"/YEAR.
ASSUME APPLICATION FOR 30 WEEKS/YEAR (MINIMUM)

MAXIMUM APPLICATION RATE = 0.25 IN/HR. (REGS-33.03.05)
ONCE PER WEEK

THUS:

$$\frac{30\ \text{INCH/YR}}{30\ \text{WEEKS/YR}} = 1\ \text{INCH/WEEK}$$

AND:

$$\frac{1\ \text{INCH/WK}}{.25\ \text{INCH/HR}} = 4\ \text{HRS/DOSE},\ 1\ \text{DOSE/WEEK}$$

FIELD AREA REQ'D

ONE ACRE-INCH = 27,152 gal.

$$\text{AREA REQ'D} = \frac{(\text{DAILY FLOW})\ \text{GAL/DAY} \times 365\ \text{DAY/YR}}{1\ \text{IN/WK} \times 27{,}152\ \text{GAL/AC.IN} \times 30\ \text{WK/YR}}$$

$$= (\text{DAILY FLOW}) \times .000448\ \text{ACRES}$$

@ PLANT CAPACITY : 35,000 × .000448 = 15.7 Ac.

@ START UP : 14,000 " = 6.3 Ac.

@ ULTIMATE : 23,600 " = 10.6 Ac.

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CALCULATED BY QSC DATE 12/06/85
CHECKED BY ______ DATE ______
SCALE ______

IF FIELD IS SIZED TO ACCOMODATE THE PLANT CAPACITY THE EFFECTIVE ONLINE RESERVE IS:

$$\frac{15.7 - 10.6}{10.6} \times 100 = 48\%$$

THIS EXCEEDS THE REQUIREMENT THAT A 25% RESERVE AREA CAPABLE OF BEING USED IN 10 DAYS (REGS. 33.02.02b)

TRY LAYOUT & CONTROLS FOR 16 INITIAL SUBSYSTEMS EACH SIZED AT 1 ACRE.

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SHEET NO ______ OF ______
CALCULATED BY GRC DATE 01/06/86
CHECKED BY ______ DATE ______
SCALE ______

POTENTIAL EVAPOTRANSPIRATION

BASED ON A FORMULA PROPOSED BY HOLDRAGE*

$$PE_T = 4.9\ T_M$$

WHERE : PE_T = POTENTIAL EVAPOTRANSPIRATION (mm)/MONTH.
T_M = MEAN MONTHLY TEMPERATURE (°C)

$$PE_T = 4.9\left(\frac{5}{9}(°F-32)\right) \times \frac{1}{25.4} \quad \frac{°F}{°C}\ \frac{in}{mm}$$

$$= 0.10\,(°F-32)\ in/month$$

MONTH	T_M (°F)	PE_T (in/month)	
JAN	22	0	(-1.1)
FEB	29	0	(-0.3)
MAR	37	0.5	
APR	46	1.5	
MAY	54	2.4	
JUN	60	3.0	
JUL	64	3.4	
AUG	64	3.4	
SEPT	57	2.7	
OCT	47	1.6	
NOV	39	0.8	
DEC	29	0	(-0.3)
TOTAL		19.3 in/year	

* FROM: OVERCASH, MICHAEL RAY, DESIGN OF LAND TREATMENT SYSTEMS FOR INDUSTRIAL WASTES - THEORY & PRACTICE, ANN ARBOR SCIENCE, 1981, pp 123.

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CALCULATED BY QSC DATE 12/24/85
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SCALE ____

APPLIED
NITROGEN LOADING

BASED ON LIMITED TESTING AND TYPICAL DESIGN VALUES THE NITROGEN CONCENTRATIONS ANTICIPATED ARE:

	TESTING	EPA*	USE FOR DESIGN	
ORGANIC (KJELDAHL)	25.	15.	25.	mg/l
AMMONIA (NH_3/NH_4)	10.	25.	15.	
NITRATES	0.4	0	0	
NITRITES	0.7	0	0	
TOTAL NITROGEN	36.	40.	40.	mg/l

SOME ORGANIC NITROGEN BOUND IN SOLIDS WILL BE REMOVED BY SEDIMENTATION WHILE AMMONIA WILL BE DRIVEN OFF DURING SECONDAY TREATMENT. WITHOUT SPECIFICALLY PROVIDING A NITROGEN REMOVAL PROCESS THE ANTICIPATED LOAD LEAVING THE PLANT WOULD BE:

APPLIED N. CONC. = 40 mg/l (1 -.20 removed)
= 32 mg/l

APPLIED N. LOAD = 32 × 8.34 × .0236 MGD
= 6.3 lb/day

AT AVERAGE FLOW = 23,600 gpd THE ACREAGE SPRAYED WILL BE 11.0 Ac.

$$\text{APPLIED N. LOAD} = \frac{6.3 \times 365}{11.0} = 209 \text{ lb/ac·yr}$$

* EPA P.D.M. LAND TREATMENT OF MUN. WASTEWATER TABLE 3-2 (p 3-14) FOR A MEDIUM STRENGTH WASTE (BOD & TSS = 200 mg/l)

treatment processes further reduces the BOD and SS, and may reduce nitrogen or phosphorus.

TABLE 3-1

APPLICABILITY OF RECOVERY SYSTEMS FOR RENOVATED WATER

Recovery system	Slow rate	Rapid infiltration	Overland flow
Surface runoff collection			
Effluent	NA	NA	Collect[a]
Stormwater	Sediment control	NA	Erosion control
Underdrains	Groundwater control and effluent recovery	Groundwater control and effluent recovery	NA
Recovery wells	Usually NA	Groundwater control and effluent recovery	NA
Tailwater			
Sprinkler application	NA	NA	NA
Surface application	25-50% of applied flow	NA	NA

NA = not applicable.

a. Disinfect if required before discharge; provide for short-term recycling of wastewater after extended periods of shutdown, if effluent requirements are stringent.

TABLE 3-2

IMPORTANT CONSTITUENTS IN TYPICAL DOMESTIC WASTEWATER [3] mg/L

From M&E

Constituent	Type of wastewater		
	Strong	Medium	Weak
BOD	300	200	100
Suspended solids	350	200	100
Nitrogen (total as N)	85	40	20
Organic	35	15	8
Ammonia	50	25	12
Nitrate	0	0	0
Phosphorus (total as P)	20	10	6
Organic	5	3	2
Inorganic	15	7	4

Land treatment processes are capable of removing large amounts of BOD and SS as well as nutrients, trace elements, and microorganisms.

TABLE 2-3

EFFECT OF VARIOUS TREATMENT PROCESSES ON NITROGEN COMPOUNDS

Treatment process	Effect on constituent			Removal of total nitrogen entering process, percent[a]
	Organic N	NH_3/NH_4^+	NO_3^-	
Conventional treatment processes				
Primary	10-20% removed	no effect	no effect	5-10
Secondary	15-25% removed[b] urea → NH_3/NH_4^+	<10% removed	nil	10-20
Advanced wastewater treatment processes				
Filtration[c]	30-95% removed	nil	nil	20-40
Carbon sorption	30-50% removed	nil	nil	10-20
Electrodialysis	100% of suspend organic N removed	40% removed	40% removed	35-45
Reverse osmosis	100% of suspend organic N removed	85% removed	85% removed	80-90
Chemical coagulation[c]	50-70% removed	nil	nil	20-30
Land application				
Irrigation	→ NH_3/NH_4^+	→ NO_3^- → plant N	→ plant N	40-90
Infiltration/percolation	→ NH_3/NH_4^+	→ NO_3^-	→ N_2	0-50
Major nitrogen removal processes				
Nitrification	limited effect	→ NO_3^-	no effect	5-10
Denitrification	no effect	no effect	80-98% removed	70-95
Breakpoint chlorination	uncertain	90-100% removed	no effect	80-95
Selective ion exchange for ammonium	some removal, uncertain	90-97% removed	no effect	80-95
Ammonia stripping	no effect	60-95% removed	no effect	50-90
Other nitrogen removal processes				
Selective ion exchange for nitrate	nil	nil	75-90% removed	70-90
Oxidation ponds	partial transformation to NH_3/NH_4^+	partial removal by stripping	partial removal by nitrification-denitrification	20-90
Algae stripping	partial transformation to NH_3/NH_4^+	→ cells	→ cells	50-80
Bacterial assimilation	no effect	40-70% removed	limited effect	30-70

[a] Will depend on the fraction of influent nitrogen for which the process is effective, which may depend on other processes in the treatment plant.

[b] Soluble organic nitrogen, in the form of urea and amino acids, is substantially reduced by secondary treatment.

[c] May be used to remove particulate organic carbon in plants where ammonia or nitrate are removed by other processes.

2.6 References

1. Sawyer, C.N., and P.L. McCarty, *Chemistry for Sanitary Engineers.* New York, McGraw-Hill Book Co., 1967.

2. Christensen, M.H., and P. Harremoes, *Biological Denitrification in Wastewater Treatment.* Report 2-72, Department of Sanitary Engineering, Technical University of Denmark, 1972.

3. Delwiche, C.C., *The Nitrogen Cycle.* Scientific American, 223, No. 3, pp 137-146 (1970).

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SHEET NO. OF
CALCULATED BY GSC DATE 12/23/85
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ALLOWABLE
NITROGEN LOADING (METHOD 1.)

BASED ON RECOMMENDATIONS FROM THE PENN STATE WORK, LOADING OF THE FOREST SYSTEM SHOULD CAUSE NO SUBSTANTIAL IMBALANCE IF THE NITROGEN LOADING RATE DOES NOT EXCEED THE AVERAGE UPTAKE RATE.

TYPICAL UPTAKE (MATURE FOREST) 30 - 50 lb/acre-yr [EPA LAND TREAT MUN. WW. pg-6]

TYPICAL UPTAKE @ SITE ≈ 60-75 lb/acre-yr [Tom Simson V.P.I Agronomy]

TO BE CONSERVATIVE USE 50 lb/acre-yr AT THE SITE

TO DETERMINE THE N CONCENTRATION WHICH WOULD BE ACCEPTABLE AT THE DESIGN HYDRAULIC LOADING, USE AREA = 11.0 AC @ DESIGN FLOW = 23,600 gpd

TOTAL LOAD = 50 lb/acre-yr × 11.0 ac. = 550 lb/yr

$$\text{MAX. CONC. } N_{TOTAL} = \frac{550 \text{ lb/yr}}{8.34 \text{ lb/gal} \cdot .0236 \text{ MG/day} \cdot 365 \text{ day/yr}}$$

= 7.65 ppm Total N APPLIED

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SCALE GSC 1/28/86

ALLOWABLE
NITROGEN LOADING (METHOD 2)

DETERMINING FIRST THE QUANTITY OF WATER PERCOLATING THROUGH THE SOIL AND ENTERING THE WATER TABLE.

$$W_p = P_r - ET + L_w$$

where: W_p = PERCOLATING WATER
P_r = ANNUAL PRECIP.
E_T = EVAPOTRANSPIRATION
L_w = HYDRAULIC LOAD OF WASTEWATER

$$W_p = 52 - 19 + 30$$
$$= 63 \text{ in/yr}$$
$$= 5.3 \text{ ft/yr}$$

FROM EPA'S PROCESS DESIGN MANUAL FOR LAND TREATMENT OF MUNICIPAL WASTEWATER THE NITROGEN LOADING IS DETERMINED BY:

$$L_n = U + D + 2.7\, W_p C_p$$

where: L_n = NITROGEN LOADING
U = NITROGEN UPTAKE
D = DENITRIFICATION
W_p = PERCOLATING WATER (ft/yr)
C_p = PERCOLATE NITROGEN CONC. (mg/l)

TO DETERMINE MAX. L_n ALLOWABLE USE C_p = 10 mg/l.
DENITRIFICATION IS IN RANGE OF 15 to 25% (EPA 625/1-81-013)
USE 15% FOR CALCULATIONS. USE CONSERVATIVE VALUE OF U OF 50 lb/acre·yr

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$$L_n = 50 + .15(2.7\,W_pC_p) + 2.7\,W_pC_p$$
$$= 50 + 1.15\,(2.7\,(5.3)(10))$$
$$= 215 \text{ lb/acre·yr}$$

AT DESIGN FLOW = 23,600 gpd AND THE AREA = 11.0 AC. TO ACCOMODATE THE HYDRAULIC LOAD:

MAX. ALLOW LOAD $= 215 \text{ lb/ac·yr } (11.0 \text{ ac})$
$= 2365 \text{ lb/yr}$

MAX. ALLOW CONC. $= \dfrac{2365 \text{ lb/yr}}{8.34 \text{ lb/gal } .0236 \text{ MG/day } 365 \text{ day/yr}}$

$= 32.9 \text{ mg/l}$

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JOB MOUNTAIN LAKE WASTEWATER
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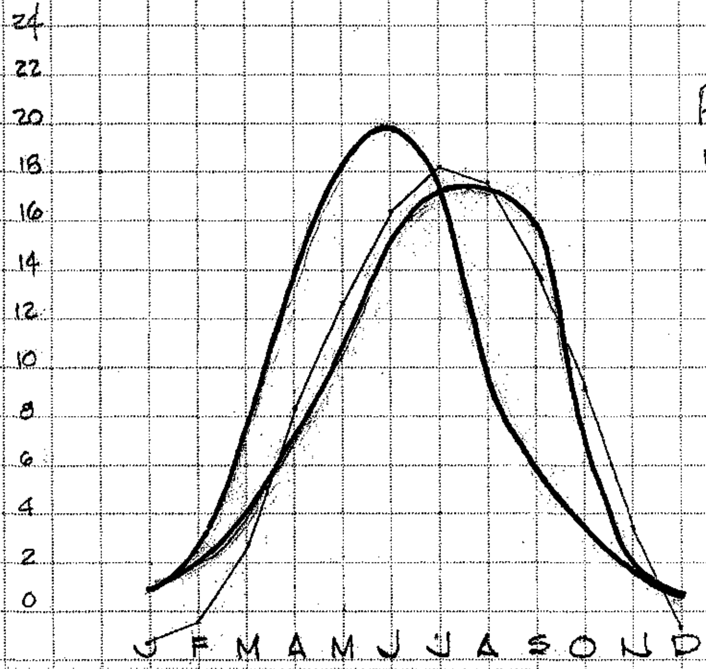
CALCULATED BY GSC DATE 5/16/86
CHECKED BY ______ DATE ______
SCALE ______

PERCENT OF ANNUAL NITROGEN UPTAKE - FOREST SYSTEM



SWAG	1	2	6	14	18	20	18	9	6	4	1	1	◁
SWAG	1	2	4	7	11	15	17	17	16	7	2	1	◁
% ET	-1.5	-.7	2.9	8.3	12.8	16.3	18.1	17.5	14.2	9.2	3.6	-0.9	USE

V. LAND AREA DETERMINATION

A. Land area requirements were computed utilizing an estimated irrigation rate of 30 acre inches/year. Section III, E4 of the Preliminary Engineering Report (P.E.R.) details sizing of the spray fields. Nutrient and metals loading computations follow for each of the constituents listed in the outline. All information contained is for raw data without adjustment. Levels of major fertilizer elements are consistent with or slightly in excess of normal needs for good tree growth. Heavy metals loading does not indicate the need for concern since all site life computations indicate long site life projections. It should be noted that these projections are conservative since computations are from influent data and will be significantly reduced during treatment.

NUTRIENT AND METAL LOADING COMPUTATIONS

Computations are based on waste characterization provided in the analysis of Mountain Lake Influent Waste, as shown in figure 2 of the P.E.R., and the following assumptions.

1. Average daily flow = 23,600 GPD
2. Annual flow = 8.61 MG = 317 acre inches
3. Irrigation rate = 30 acre inches/year
4. Primary irrigation area = 11.0 acres

All loading computations (Nutrients and Metals) will contain the following generalized computation.

$$\frac{(\text{concentration mg/l})\ (0.0236\ \text{MGD})\ (8.34)\ (365\ \text{days/year})}{11.0\ \text{acres}} = \text{lbs./acre/yr.}$$

Simplified this equation becomes
(concentration in mg/l) (6.53) = lbs./acre/year

NITROGEN LOADING 21 mg/l (following treatment)

(21) (6.53) = 137 lbs./acre/year

Approximately 20% will be lost to volatilization and denitrification at the ground surface.

PHOSPHORUS LOADING 6.2 mg/l

(6.2) (6.53) = 40 lbs./acre/year
(40 lbs./acre/year) (2.29) = 92 lbs. P_2O_5/acre/year

POTASSIUM LOADING 21.9 mg/1

(21.9 mg/l) (6.53) = 143 lbs./acre/year
143 x 1.2 = 172 lbs. K_2O/acre/year

SULFUR LOADING 16.5 mgl sulfate

The interim drinking water standards allow 250 mg/1 of sulfate. The sulfur contact of this effluent is below that level and filtrate reaching the ground water system will meet drinking water standards with respect to sulfate concentrations.

SODIUM LOADING 78.9 mg/1

$$SAR = \frac{Na}{\sqrt{\frac{Ca \quad + \quad Mg}{[Ca \quad ++ \quad Mg++ \quad]/2}}} = \frac{\frac{78.9}{23}}{\sqrt{\frac{\frac{12.6}{20} + \frac{1.8}{12}}{2}}} = \frac{3.43}{0.62} = 5.5$$

TOTAL OXYGEN DEMAND C.O.D. = 60 mg/1 B.O.D. 30 mg/1
(estimated for treated waste)

(90) (6.53) = 588 lbs. acre/year

NICKEL LOADING <0.2 mg/1

(0.02) (6.53) = 0.13 lbs/acre/year

Site Life = $\frac{44}{0.13}$ = 338 ± years

COPPER LOADING 0.05 mg/1

(0.05) (6.53) = 0.33 lbs./acre/year

Site Life = $\frac{111}{0.33}$ = 336 ± years

ZINC LOADING 0.04 mg/1

(0.04) (6.53) = 0.26 lbs./acre/year

Site Life = $\frac{222}{0.26}$ = 854 ± years

LEAD LOADING 0.30 mg/1

(0.30) (6.53) = 1.96 lbs./acre/year

Site Life = $\frac{445}{1.96}$ = 227 ± years

CADMIUM LOADING 0.006 mg/1 (below detection limits)

(0.006) (6.53) = 0.04 lbs./acre/year

Site Life = $\frac{2.22}{0.04}$ = 55.5 ± years

ARSENIC LOADING 0.005 mg/1
Not applicable; very low concentrations in effluent.

BORON LOADING 0.18 mg/1

(0.18) (6.53) = 1.18 lbs./acre/year

Boron is essential for plant growth and is required by most plants. Available data indicates that irrigated grasses will remove 0.5 to 1.0 pound of boron per acre annually. Available information indicates that an acceptable leachate concentration for boron is in the order of 0.75 to 2.0 mg/1 (average = 1.375 mg/1). Since boron is a common constituent of ground water, allowable boron effluent concentrations in the order of 1.0 mg/1 to 2/0 mg/1 are rational. The concentration of boron in the influent is within the concentration range for use on plants which are Boron sensitive (see Overcash & Pal, page 378).

CHLORIDE 47 mg/1

(47) (6.53) = 307 lbs./acre/year

Chloride is an essential plant element and is highly volatile and very mobile in the soil profile. Since there is little absorption or precipitation of Cl in soils, there is little reason for concern with this effluent. The percolate will meet drinking water standards with respect to chlorine.

B. A partial evaluation of land area requirements and the annual water balance are contained in Section III, E3. The water balance computations will be completed after the storage facilities have been designed and all pertinent parameters are known.

REFERENCES CITED:

Overcash & Pal: 1981; Design of Land Treatment Systems for Industrial Wastes; Ann Arbor Sci.

ATTACHMENT I

Excerpt from Mountain Lake Wastewater Treatment Plant O&M Manual

A wide variety of sprinkler heads are available. Durability and corrosion resistance influenced the final nozzle selection. Plastic heads with maximum opening size standard brass nozzles are used. Brass sprinklers are usually recommended for frost control applications because of the potential for freezing. The system will not be operated during the winter and is designed to drain the sprinkler riser to prevent sprinkler damage during intermittent cold weather.

The irrigation system controls are the most complex component of the irrigation system. The controls allow automatic or manual dosing of each spray field subsystem. Timers control the frequency and duration of the opening of each subsystem control valve as well as the pumps. A precipitation switch is also used to "lock out" dosing during times when excessive precipitation has occurred.

b. Dosing Rates

The rate at which the forest is dosed by the spray irrigation system is dependent on many factors. These factors include the wastewater production rate, precipitation, soil permeability, and nitrogen uptake rate of the forest. Many factors were used in the design of the system and now that the system is constructed are not readily variable. The operator's principal control over the system consists of: making sure all components of the system function as designed, and controlling the wastewater application rate by varying the pumping time.

The ability of the spray irrigation area to accept and treat the effluent is limited in two ways. First, effluent should not be dosed at a rate faster than it can percolate into the soil. To function properly, the effluent must slowly pass through the forest mat and underlying soils before it reaches the groundwater. The hydraulic loading thus affects the soils ability to act as a filter. If dosing rates are too great, or if effluent is applied to saturated or frozen soils, it may not soak in. The excess effluent would then run off the surface and eventually make its way to one of the streams.

The second limitation is based on the ability of the forest to use the nitrogen present in the wastewater. The nitrogen present in the effluent must be reduced to an acceptable level so that groundwater leaving the site does not have a nitrate content exceeding 5 mg/l. High nitrate content in the water supply can be fatal to feeding infants. The nitrogen in the effluent is reduced by being taken up and used by forest plants, and through the process of denitrification.

In the Mountain Lake system, the application rate is more limited by the forest's ability to handle the nitrogen in the wastewater than by the soils ability to accept the additional water. Thus the allowable loading rates are controlled by how much nitrogen is applied. Under normal operation the treatment plant should be able to produce an effluent with a total nitrogen content of less than 20 to 25 mg/l (TKN). Based on this, and estimates of the fluctuation in the nitrogen uptake in the forest during the year, typical loading rates have been computed. These rates are expressed as inches of effluent applied per acre. Because plants use more nitrogen while growing, the number of inches of effluent applied can be greater during the spring and summer than in the fall and winter.

The target monthly loading rates at design flow are listed below.

January	0.0	inches/acre/month
February	0.0	
March	2.3	
April	2.5	
May	3.2	
June	3.7	
July	4.0	
August	3.7	
September	3.2	
October	2.3	
November	1.8	
December	0.0	

Annual Loading 26.8 inches/acre/month

The irrigation pumps are fixed speed pumps. The pumps pump more water when there is less backpressure or "head" and pump less water as the pressure or "head" increases. Because the spray field varies in elevation, the pumps pump more water when pumping to the lower spray fields than when they pump to the higher spray fields. It is desirable to dose all spray fields at the same number of inches per acre. Each spray field is the same size (approximately 1 acre). Thus we can control the dosing rate by controlling the dosed volume. This is done by knowing the relative pumping rates to each spray field. For ease of operation, groups of spray fields are dosed at the same time. Each pump has the capacity to dose 3 low spray fields or 2 high spray fields at the same time. Only one pump operates at a time while the other serves as a backup if needed.

The system is set up to dose the following spray fields at the same time:

S-1, S-2, S-3	together
S-4, S-5, S-6	together
S-7, S-8	together
S-9, S-14	together
S-12, S-13	together

S-10, S-11, S-15, S-16 are not dosed but are held as reserve sites

The Health Department required that four acres of reserve spray field be constructed in the event they are needed in the future. The highest sites are used for reserve areas so that effluent from a failing or improperly operated site does not flow over or through the reserve sites. Also the pumping costs are less to pump to the lower sites.

The dosing rate is then controlled by the operator by controlling the amount of time the effluent is applied to each spray field. This is done by the use of a programmable controller located in the Irrigation Pump Station. Complete instructions on the use and programming of the controller are contained in irrigation system equipment file. The rest of this section is dedicated to the time settings for each group of spray areas.

c. Normal System Settings

The dosing rate (inches/month/acre) is controlled by the pumping rate (gallons per minute - gpm) and the time we run each pump. For ease of operation we will adjust the system so that the pumps are always pumping at the same dosing rate (inches/month/acre). This rate is initially set at 47 gpm per spray field, since each spray field is approximately one acre. The design calculations have been reduced to a graph which can be used to determine the desired pumping rates (see Attachment V-6). Each spray field contains six sprinkler heads which each dose at 7.8 gpm. Thus, the total for each field is 6 x 7-8 or about 47 gpm. The desired pumping rates are thus:

1 spray field	47 gpm
2 spray fields	94 gpm
3 spray fields	141 gpm

To obtain the desired pumping rates, we control the discharge pressure. This is done by throttling the control valves for each spray area. The valves used are a "combination" type control valve. The flowrate through the control valve is set by setting the discharge pressure. The desired discharge pressure at each spray head is 32 psi. This is obtained by connecting a pressure gage to the valve during pumping and turning the valve control handle. The desired pressure setting at the valve is the sum of the desired setting at the spray head plus the typical headloss in the spray header pipe. The maximum headloss is about 4.0 psi at the end of the pipe while the average or typical headloss to sprayheader is 2.0 psi. Thus, the control valve setting should be 32 + 2 = 34 psi.

To obtain the required pump run time at any desired dosing rate, you should first convert your dose to gallons using the formula:

$$\text{gal/mo} = \text{Ac in/mo} \times \frac{(43560\ \text{ft}^2/\text{Ac})}{(12\ \text{in/ft})} \times 7.48\ \text{gal/ft}^3$$

$$= 27{,}152 \times \text{Ac in/mo}$$

Once you know how many gallons you want to pump to each sprayfield each month, you can determine how many minutes each month your pump will have to run by dividing by the pumping rate:

$$\text{min/mo} = \frac{\text{gal/mo}}{\text{gal/min}}$$

$$= 0.0213 \times \text{gal/mo}$$

If we assume that we will only pump every other day or 15 days per month because of bad weather, we can determine the pump run time required for each dose by:

$$\text{min/dose} = \frac{\text{min/mo}}{\text{doses/mo}}$$

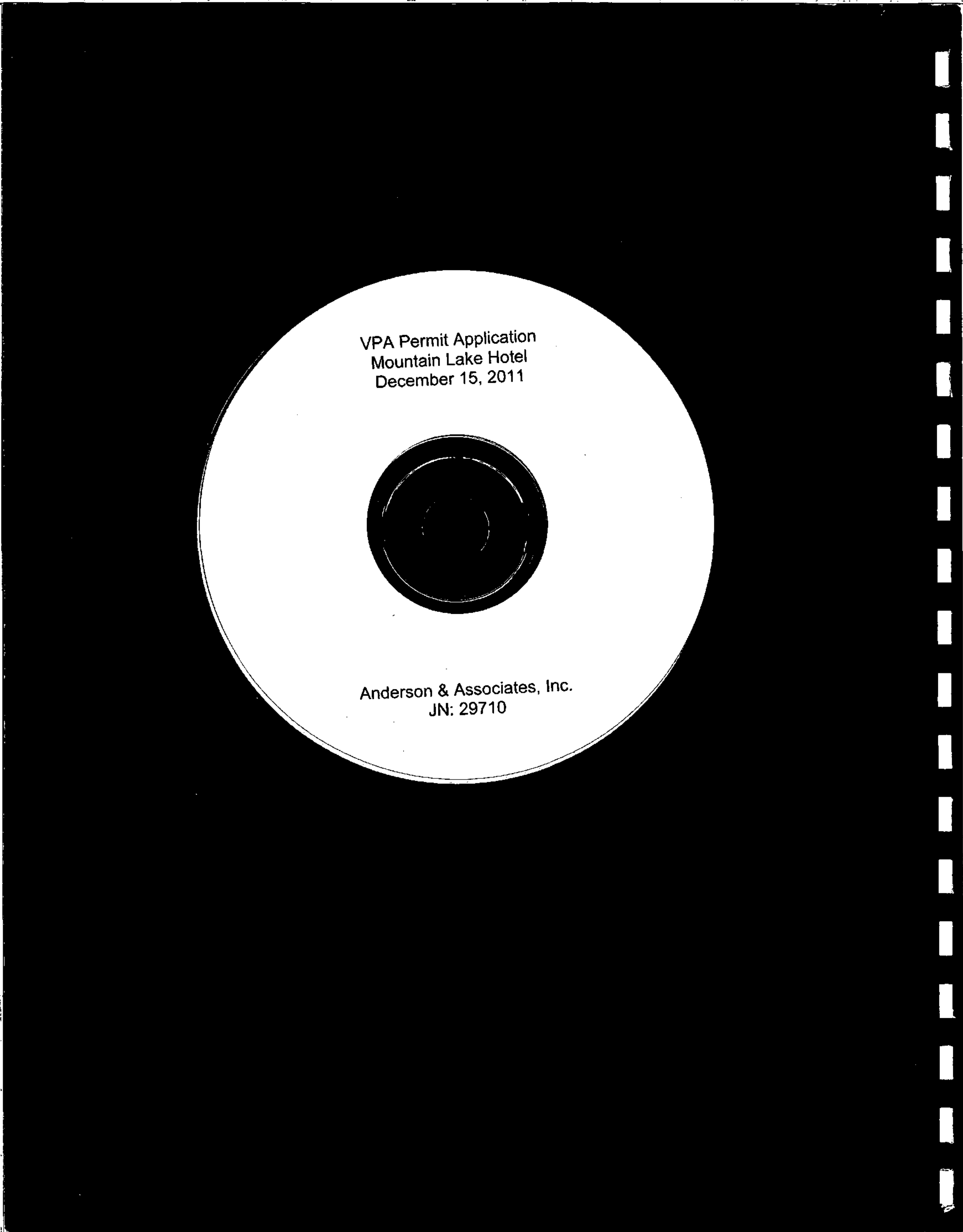
$$= 0.0666 \times \text{min/mo}$$

Thus, under normal design conditions the pumping is set each month in accordance with the following schedule.

Required Dosing Times at Design Flowrates & Loadings

Control Valve Discharge Rate ....:	47 gpm
Number Days Dosed per Month ....:	15 doses/mo

MONTH	DOSING RATE (acre in/mo)	DOSING RATE (gal/mo)	DOSING TIME (min/mo)	DOSING TIME (min/dose)
January	0.0	0	0	0
February	0.0	0	0	0
March	2.3	62450	1329	89
April	2.5	67880	1444	96
May	3.2	86886	1849	123
June	3.7	100462	2137	142
July	4.0	108608	2311	154
August	3.7	100462	2137	142
September	3.2	86886	1849	123
October	2.3	62450	1329	89
November	1.8	48874	1040	69
December	0.0	0	0	0
TOTAL ANNUAL	26.7	724958	15425	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